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THE POPULAR Science Review

EDITED BY W. S. DALLAS, F.L.S.

Assistant-Secretary of the Geological Society.

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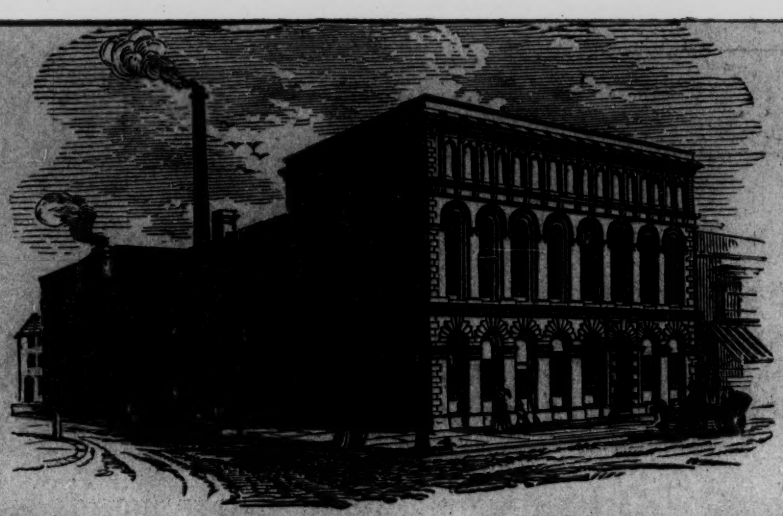

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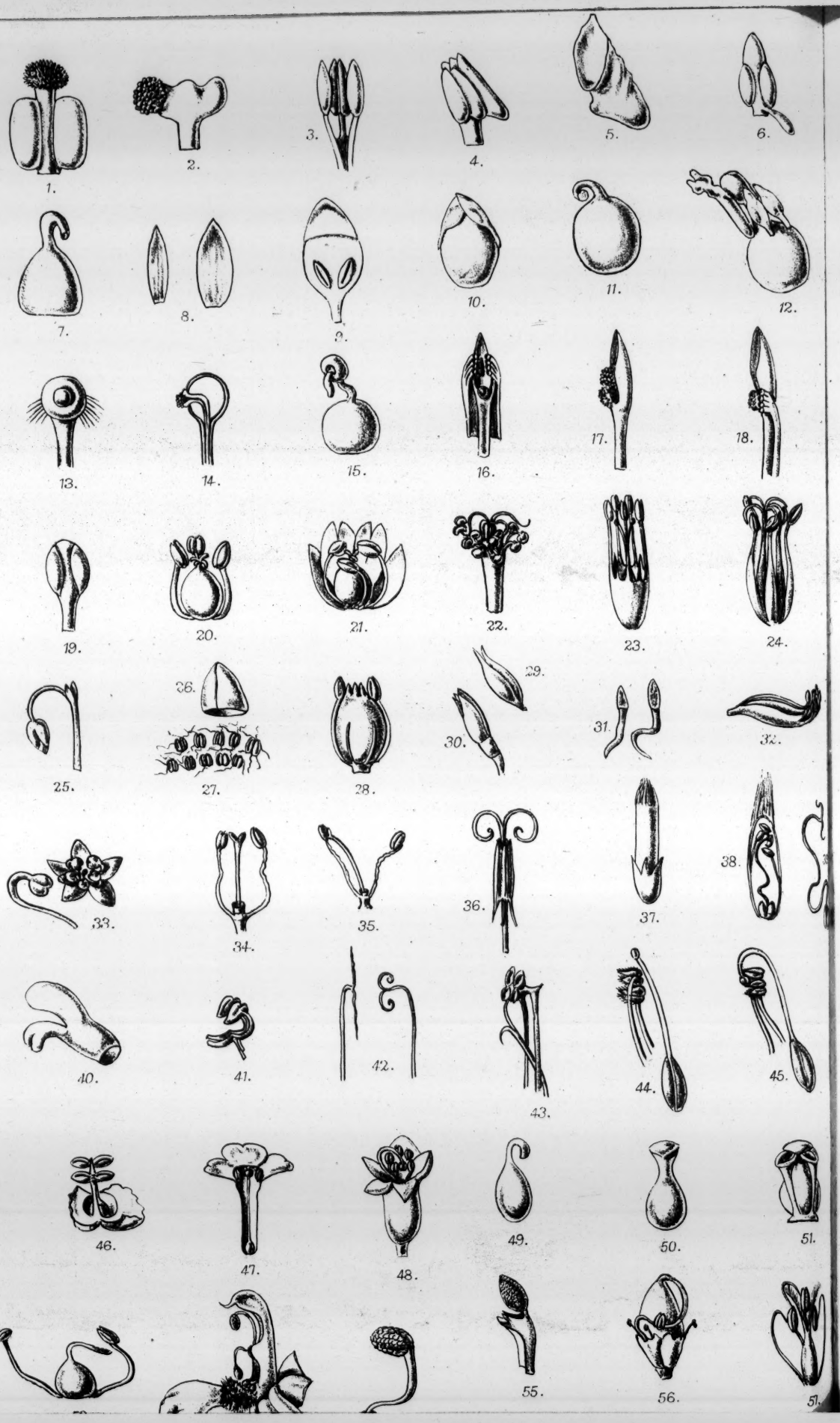
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POPULAR SCIENCE REVIEW.

THE SELF-FERTILISATION OF PLANTS.*

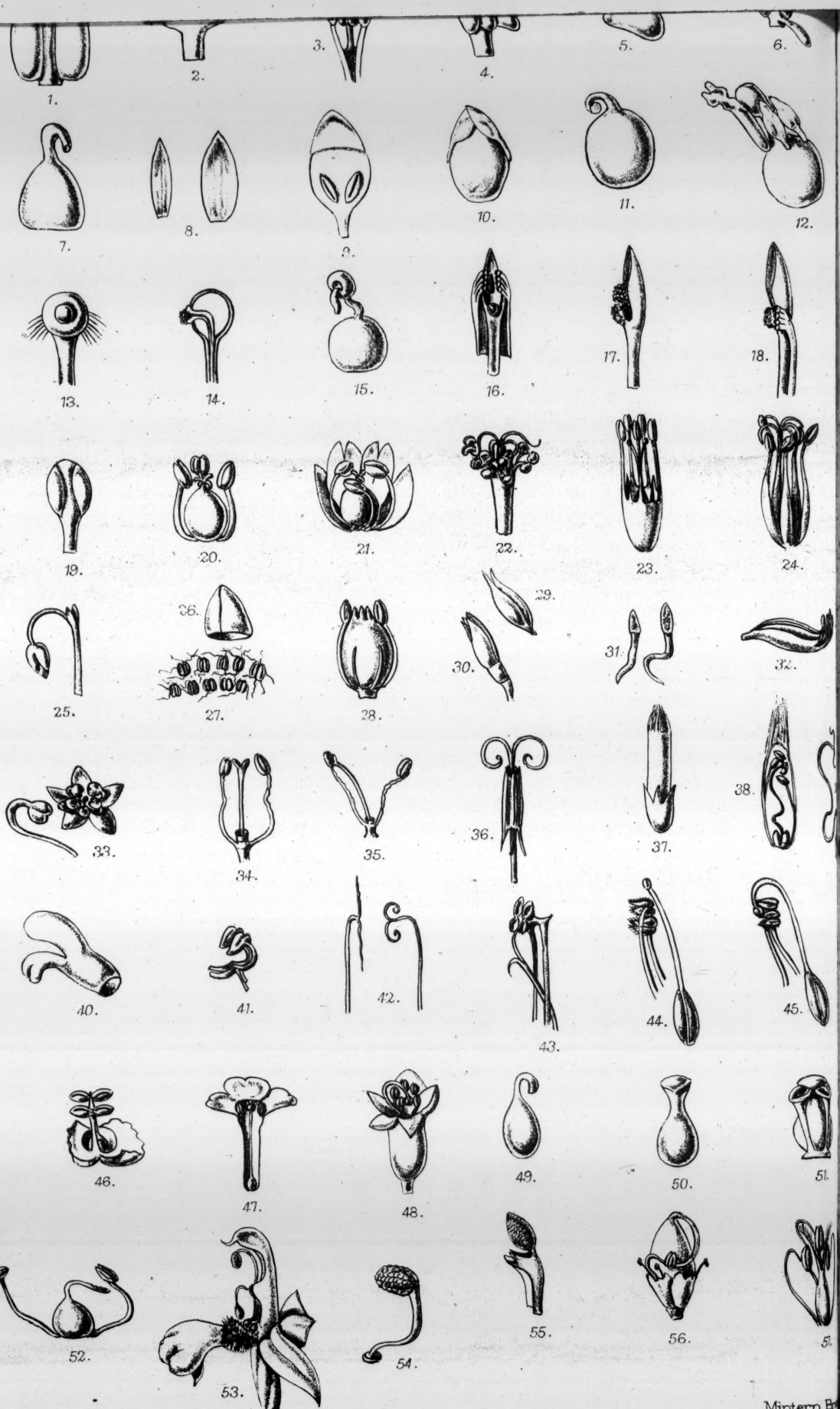
By the Rev. GEORGE HENSLOW, M.A., F.L.S., F.G.S.

[Plate I.]

When the discovery that plants had sexes became a well-recognised fact, the relative position of the stamens and pistil in a flower was noticed as peculiarly favouring, as was supposed, their union; and in accordance with the teleological views of the last century, the oft-quoted generalisation was made (attributed, I believe, originally to Linnæus), that whether a flower be pendulous or erect, the stigma was always *below* the anthers, so that the pollen might *fall* upon it, self-fertilisation being thus supposed to be the object in nature.

It is worth while pointing out some objections to this idea. In the first place, if nature intended the pollen to reach the stigma, why, it may be asked, is it allowed to *fall*, as it would be applied to it with much more certainty if the anthers were placed in close contact with that organ, as is actually the case in all really self-fertilising plants, so that there would be no chance of the pollen being blown away by the wind before it could fall down upon the stigma. Secondly, how comes it that flowers are monœcious and dicœcious, that is, with their sexes separate, either in different flowers on the same or on distinct plants, respectively? Thirdly, many flowers, though possessing both stamens and pistil, are dichogamous, that is, the anthers mature and shed their pollen before the stigma is ready to receive it; or else the stigma matures before the anthers. Lastly, a large proportion of conspicuous flowers are irregular or else

* The subject of a paper by the present writer in the "Transactions of the Linnæan Society," to be published in the ensuing volume.



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SELF-FERTILIZING FLOWERS.

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* The subject of a paper by the present writer in the "Transactions of the Linnæan Society," to be published in the ensuing volume.

highly attractive to insects, and, as has been shown by Sprengel in 1790, and by various botanists at the present day, are specially adapted to insects who transfer the pollen from one flower to another.

The effects of the last-mentioned process have been ascertained and described by Mr. Darwin in his work on "Cross and Self-Fertilisation of Plants." He proved, by experiments, that when ordinary garden plants are crossed by others of the same stock, or by others of a different stock of the same species, the offspring generally showed greater vegetative vigour in growing taller and in bearing more vigorous and greener foliage; while in their reproductive organs there was brighter and greater variation in colour, and often more seed was set than when such plants had been continuously self-fertilised.

The results would seem, therefore, to exactly fulfil an inference which the late Dean Herbert drew from his experiments with bulbous plants, and which he has recorded in his work on the *Amaryllideæ* (p. 70), as follows:—"I am inclined to think I have derived advantage from impregnating the flowers from which I wish to obtain seeds, from individuals of another variety or another flower, rather than its own, and especially of any grown in different soil or aspect."

A very considerable amount of literature now exists on the subject of cross fertilisation by insect agency. The beautiful and exquisite adaptations exhibited by so many conspicuous flowers have attracted the attention of observers, so that whoever sets to work to examine flowers with this object in view, is pretty sure of making new discoveries of special adaptations.

So obvious, then, has the importance of insect agency been thought to be, that the inference has been drawn that cross fertilisation is necessary for flowers; and Mr. Darwin generalised this inference into an aphorism, which may be regarded as expressing the exactly opposite view to that attributed to Linnæus, namely, that "Nature abhors perpetual self-fertilisation." We may contrast these opposite poles of thought, somewhat as follows:—With Linnæus, Nature had specially designed (most?) flowers to secure self-fertilisation. With Darwin, Nature has specially adapted (most?) flowers to avoid self-fertilisation.

I add "most?" because these observers do not fail to see that there are exceptions in both cases.

Opinions have often been compared to a pendulum, whether they be political, ecclesiastical, or otherwise, in that for a time they run high in one direction; but a reaction sets in and down they go, and are then carried up to the opposite extreme. It is not till both extreme forms have been well tested that at last the excesses in both are struck off, and the truth which invariably underlies each is at last recognised, and the "golden mean" is

then permanently secured in their combination, and the pendulum comes to rest.

Such I believe to be the case with the question before us; for I think I can show that Darwin's aphorism is wrong in its extreme form, if not altogether; and the object of the present paper is to endeavour to combine the twin truths which underlie the cross and self-fertilisation of plants.

Mr. Darwin's works have gone far to strengthen the belief that intercrossing is absolutely necessary for plants; and that if self-fertilisation be continued for lengthened periods the plant tends to degenerate and thence to ultimate extinction. This I believe to be absolutely false. Indeed, so strong is the general belief in the value of intercrossing, that self-fertilisation is kept quite in the background, if at all alluded to, by writers on this subject; so that flowers are now usually classed either as "entomophilous," *i.e.*, adapted to insect agency, or else as "anemophilous" or wind-fertilised.

When Mr. Darwin examined Orchids and wrote his excellent book on their fertilisation, he was struck with the singular exception of the "Bee-orchis" (*Ophrys apifera*), which is so constructed as to fertilise itself; and yet this plant is one of the most abundant of orchids, a vigorous grower, and shows no signs of degeneracy at present. Another case, amongst many others mentioned in his "Cross and Self-fertilisation of Plants," is that of the garden pea, which is constantly self-fertilised in this country, and yet the papilionaceous corolla is manifestly and specially adapted to insects. Mr. Darwin alludes to Mr. A. Knight's varieties, originally obtained by crossing, as having lasted for upwards of sixty years, by self-fertilisation alone; and the inference in both cases is, that the effects of crossing—in the ancestral form of the Bee-orchis, which doubtless required it, and in the artificial crossings made by Mr. Knight—have lasted, to the present day in the first case, and for sixty years in that of the pea.

Moreover, since a great number of plants are now discovered to be in the habit of setting seed, and that too very freely, without insect aid, a further generalisation has been made, that not only were they originally crossed, and the good effects have lasted till now, that is to say, for practically an indefinite series of ages; but that they *must* be occasionally crossed again, or they will inevitably die out in time.

Now it must be carefully noted that these generalisations are entirely subjective or *à priori* inferences, based upon the *assumed* necessity of crossing; that assumption being itself based upon the vast number of adaptations to insect agency which exist; but the fact that self-fertilisation is really of wider extent in the vegetable kingdom is ignored. On the other hand, the belief appears to be generally held that many flowers

are specially adapted ("purposed") to prevent self-fertilisation. This I am convinced is an erroneous assumption.

Researches into the structure of flowers have led me to draw the following conclusions:—*

1. *The majority of flowering plants can, and probably do, fertilise themselves.* Independently of arriving at this conclusion from a study of nature, I infer it from Mr. Darwin's results; for he protected a number of plants from insects, and gives two lists of forty-nine species in each, the one of plants more or less self-fertile, and the other self-sterile without insect aid; but he adds:—"I do not, however, believe that if all known plants were tried in the same manner, half would be found to be sterile within the specified limits." †

2. *Very few plants are known to be physiologically self-sterile* when the pollen of a flower is placed on the stigma of the same flower. The genus *Oncidium* is a remarkable instance, the pollen of some species having even a poisonous action on the stigma.‡ *Linum*, as Mr. Darwin has shown, is another case, and he observes of *L. perenne* that "its own pollen is as powerless on the stigma as so much inorganic dust."§

3. *Several plants are known to be morphologically self-sterile*, in that the pollen cannot, without aid, reach the stigma, but is effective on that of the same flower. Species of Lupine and *Salvia* are in this condition.

4. *Self-sterile plants from both the above causes can become self-fertile.* Various conditions appear capable of bringing this about. A lowering of temperature seems to check the vigour of the stamens in a normally proterandrous flower, and by not affecting the pistil equally, the essential organs now mature together. Thus *Eschscholtzia*, which is self-sterile in Brazil, became, with Mr. Darwin, self-fertile in England. The mere withering of the corolla will often secure self-fertilisation, as in the case of pansies (see Plate I., fig. 12) by pressing the anthers or pollen on to the stigmas. The closing of the corolla in the evening may do the same, as with Buttercups, *Anagallis*, *Convolvulus*, and other of the Gamopetalæ, in which the stamens, being adherent to the corolla, the latter, when well expanded in sunlight, causes the stamens to spread away from the pistil, and in this condition the flowers are ready to receive the visits of insects; but by closing, the corolla carries the stamens back again, and so self-fertilisation may be secured.

* Space will only allow me to give but little more than an enumeration, but the reader is referred to my paper (*loc. cit.*), where each of these conclusions is dealt with *in extenso*.

† *Loc. cit.* p. 370.

‡ "Animals and Plants under Domestication," ii., p. 135.

§ "Forms of Flowers," p. 98.

A very common condition is for the perianth to remain scarcely at all opened, so that the stamens are never removed from contact with the stigmas. This is the case with small-flowering species of *Veronica* and *Cerastium*, while *Polygonum Convolvulus* and *Hydropiper* never, so far as I have observed them, open their perianths at all.

It would seem probable that plants habitually crossed in their native country, and well adapted for insect agency, may become quite independent of insects in another. Thus the Sweet Pea, though crossed in South Europe, is quite self-fertile here, as is also the garden Pea. The genus *Phaseolus* furnishes a very remarkable illustration, for while *P. vulgaris*, the forcing-bean, is fully self-fertile, yet *P. multiflorus*, the scarlet runner, is dependent on the visits of humble bees for its full fertility; consequently for many years there have been complaints *near London* of the failure of the crops of scarlet runners, all sorts of remedies having been suggested except the right one, which is to abandon it altogether and to grow only the kidney bean instead.*

5. *Highly self-fertile forms may arise under cultivation.* This I take from Mr. Darwin's experiments. In cultivating *Ipomœa purpurea* and *Mimulus luteus* for several generations and comparing the results of crossing and of self-fertilisation, in both cases a self-fertilising form appeared which completely outstripped its crossed competitors. In the latter case "the self-fertilised plants [of the seventh generation] consisted exclusively of this variety;" so it was useless to continue the experiments.†

6. *Special adaptations occur for self-fertilisation.* I have already mentioned a few above, such as the perianth closing or scarcely opening; and will now describe some taken from genera of the natural orders in their usual sequence.

RANUNCULACEÆ.—In small-flowered *Ranunculi*, as *R. hederaceus*, the stamens, instead of spreading away from the stigmas, remain arching over them, and so shed their pollen on to the stigmas. The same occurs with small-flowered *Potentillas*. Some flowers first spread their stamens away, and then incurve them afterwards, as *Agrimonia* (fig. 33) and *Alisma* (fig. 52).

FUMARIACEÆ.—*Fumaria officinalis.*—Mr. Darwin found this to be perfectly self-fertile when insects were excluded. The stigmas resemble two horns, each of which is thrust into a three-sided chamber formed by the three anthers, which have their filaments coherent (figs. 2 and 3).

CRUCIFERÆ.—Large-flowered species are adapted for inter-

* See "Gardener's Chronicle," 1878, p. 561.

† For further details, see "Cross and Self-Fertilisation of Plants."

crossing, though all can probably fertilise themselves by their longer stamens. Small and inconspicuously flowering species are probably in all cases regularly self-fertilised, while some, as Shepherd's-purse, are most abundant and vigorous. The stigmas of these are not two-lobed, but capitate (fig. 1).

VIOLACEÆ.—The genus *Viola* furnishes remarkable cases. The conspicuous flowers of the sweet Violet, adapted to insects, often fail to set seed; but the cleistogamous buds seed profusely. These are degraded buds of the ordinary kind, for in strong growing garden plants transitions can be found, as shown in fig. 4, which represents a bud with the calyx removed. Fig. 5 is a spurred petal, and fig. 6 a stamen with the appendage from another bud; but neither the spur nor the nectary are now of any use. Fig. 7 is the pistil with its curved style, upon which the anthers are pressed. Fig. 8 shows the rudimentary petals of a wild cleistogamous bud of Violet. Fig. 9 is a stamen. Fig. 10 is the pistil, the ovary of which after fertilisation swells and elevates the stamens, which remain clinging to the summit. Fig. 11 is the pistil with the anthers removed, showing the curved style.

Viola tricolor has not cleistogamous buds, but self-fertilising "forms" instead. H. Müller has described one form.* Fig. 13 represents a form of var. *arvensis* which I found having a peculiar development of the placenta. It formed a pillar-like process, which rose up from the "throat" fig. 14 and protruded from the orifice in the globular "head." Pollen-tubes penetrated the centre of the pillar in abundance. Fig. 15 is another form, in which the placentiferous process was lengthened out over the "lip," and resembled a long tongue, which thus licked up the pollen from the calcarate petal.

POLYGALACEÆ.—*Polygala*, though clearly adapted to cross-fertilisation, is yet often self-fertilised. The anther cells grip the spoon-like process on either side, and pour their pollen into it; then the stigma becomes pollinated by bending back upon it according to Hildebrand, from whom fig. 17 is taken. In one form which I found, the anthers were on an exact level with the stigma, so that the pollen tubes were penetrating it from either side (fig. 18).

CARYOPHYLLACEÆ.—This order supplies many "weeds," and weeds are mostly self-fertilising. Fig. 19 represents a bud of *Spergula arvensis*, which remained quite closed (in January), but was seeding freely all the while. Fig. 20 is the same with the calyx and corolla removed. Chickweed behaves in the same way (fig. 21). Both of these, like Shepherd's-purse, will blossom and fruit all the year round as long as the weather wi

* See "Nature," Nov. 20, 1873.

permit, but often without or scarcely opening their flowers in the winter months.

MALVACEÆ.—Large-flowered species of this order are strongly proterandrous. Thus *Malva sylvestris* will have shed all its pollen before the stigmas are elevated; but *M. rotundifolia*, as Müller has shown, is self-fertile, by the stigmas maturing simultaneously with the anthers, and bending down to intertwine themselves amongst the latter (fig. 22). The curvature of the stigma to secure self-fertilisation is generally due to the more rapid growth of the pistil under confinement of the petals, so that the styles are forced back. This position is then retained on the expansion of the flower.

LINACEÆ.—Though the genus *Linum* has species usually dimorphic and physiologically self-sterile, it must be understood that these conditions are not absolute and unchangeable. There is no reason for supposing they cannot be lost in any case, as indeed they often are in some. Thus the Clove Pink is strongly proterandrous, yet became self-fertilising in three generations with Mr. Darwin. *Linum perenne* was physiologically self-sterile with Mr. Darwin, yet Mr. Meehan has found an instance of its being quite self-fertile in America. *Linum catharticum* on the other hand is not dimorphic at all, and can be crossed or self-fertilised (fig. 23).

GERANIACEÆ.—Our wild species of *Geranium* furnish interesting transitional conditions from the proterandrous state to the self-fertilising, the former being seen in large-flowering forms, as *G. pratense;* the latter in the smaller ones, as *G. pusillum.** The common garden *Pelargoniums* are usually proterandrous, often strongly so, as the "oak-leaved" or "lemon-scented;" but pale-flowered "scarlet-geraniums" (*P. zonale*) are perfectly self-fertilised by the stigmas being scarcely elevated above the anthers, and recurving amongst them (fig. 24).

Oxalis and *Impatiens* have cleistogamous flowers. Figs. 25–28 represent the former, and figs. 29–31 the latter.†

LEGUMINOSÆ.—The papilionaceous corolla is obviously adapted to intercrossing, and in some cases the flowers are morphologically self-sterile; but there are many small-flowered species which are self-fertilising (fig. 32).

ROSACEÆ.—The remarks made about *Ranunculus*, which has many stamens like the Rosaceæ, apply to this latter order. Several small-flowered species, as *Potentilla Fragrariastrum*, retain the incurved position of the stamens; others, like *Agri-*

* For details, see Lubbock's "British Wild Flowers in relation to Insects," p. 43.

† For descriptions, see below, p. 13.

monia, spread them out on first opening, but bend them in again subsequently; while in others, though the outermost stamens may mature before the carpels, yet the inner will mature together with them, so that both intercrossing and self-fertilisation are possible.

ONAGRACEÆ.—*Epilobium angustifolium* and *hirsutum* are proterandrous, but the small-flowered species scarcely open their blossoms at all, and the pollen-tubes may be easily seen penetrating the stigmas from the grains within the anther-cells, which thus become "glued" to the stigmas. Figs. 34 and 35 represent the stamens and pistil of *Circœa lutetiana*. On first expanding, the anthers are close to the stigma, but they afterwards spread away as if adapting themselves for insect fertilisation. The stigma, however, has often become pollinated early, and is thus dragged to the side by sticking to the anther.

COMPOSITÆ.—Contrary to the general opinion, many of this order appear to be constantly self-fertilised. Fig. 36 shows how the stigmatic branches in the *Cichoraceæ* become strongly recurved so as to penetrate amongst the pollen-grains. Independently of that, however, some of the grains mostly fall into the "cleft." In Groundsel the stigmatic arms are often retained below, but separate, within the anther-tube, and so self-fertilisation is secured. Indeed the heads of this order constitute a sure way of securing seed, for the florets can impregnate one another, which is quite equivalent to self-fertilisation.

LABIATÆ.—This order, with its highly differentiated corolla, is obviously adapted to be intercrossed, but it has, like most, if not all others, self-fertilising species. Thus *Lamium amplexicaule* has cleistogamous flowers (fig. 37–39); while *Salvia clandestina* has its stigmas recurved between the anthers (figs. 40–42). *Prunella* (fig. 43) is also often self-fertilising.*

SCROPHULARIACEÆ furnishes several self-fertilisers, though of course, as in the Labiatæ, the great variations in the corollas are so many special adaptations to insects. Some genera, like *Euphrasia* and *Rhinanthus*, are dimorphic: one form with a larger corolla has the stigma thrust forward as in fig. 44, but the other and smaller flower has the stigma strongly recurved so as to reach the anthers (fig. 45). The common garden *Calceolaria* (fig. 46) is quite self-fertile, the stigma being in close conjunction with the anthers; but there are several species, such as *C. glutinosa* and *Pavonia*, forming the section "*Aposecos*" (see "Genera Plantarum," sub nom.), which have the anthers disjoined with a long connective between them, so that they oscillate exactly like the anthers of the genus *Salvia*.

PRIMULACEÆ.—The genus *Primula* has several species di-

* For descriptions, see below, p. 14.

morphic, but others, such as *P. scotica*, are not; and *Primula veris* and others which are usually dimorphic can become homomorphic, as in fig. 47, which is a short-styled form of the Primrose (according to the position of the anthers), but self-fertilising in consequence of the style having elongated. *Glaux maritima* (fig. 48) has the style often recurved so as to secure pollination.

PINGUICULACEÆ.—*P. lusitanica* is self-fertilising by the stigma being recurved and dipping into the two gaping anther-cells, as represented in fig. 51.

POLYGONACEÆ.— Conspicuously flowering species like the Buckwheat, which is dimorphic, and *P. Bistorta*, with pink flowers, are attractive to insects; but Müller has shown that *P. aviculare*, with its minute blossoms, and without honey-glands, is self-fertilising, while *P. Convolvulus* and *P. Hydropiper* appear to me to be habitually cleistogamous.

ALISMACEÆ.—The stamens of *Alisma Plantago* in the first stage of the flower are spread away as represented by the left-hand stamen in fig. 52, but subsequently they bend back; and, although the anthers are extrorse, they lie immediately over or among the stigmas, which are also bent towards them, as in the right hand of fig. 52.

ORCHIDACEÆ.—This order, as is so well known, is almost entirely dependent upon insect aid for fertilisation, yet the Bee Ophrys is self-fertilising, in consequence of the pollinia falling out of the anther-cells, and being retained by their glands, swing backwards and forwards, and so strike against the stigma (figs. 53 and 54). The other case mentioned by Mr. Darwin is *Cephalanthera* (fig. 55), of which he remarks:—"Whilst the flower is still in bud, or before it is as fully open as ever it becomes, the pollen-grains which rest against the upper sharp edge of the stigma (but not those in the upper or lower parts of the mass) emit a multitude of tubes, deeply penetrating the stigmatic tissue." *

COMMELYNACEÆ.—I have figured a case of self-fertilisation in *Tradescantia erecta*, which I found at Kew (fig. 56). It was late in the autumn of 1876, and none of the flower-buds expanded. The corolla in all cases withered within the bud, and several of the stamens were imperfect; the style was bent down beneath the shrivelled corolla, and was pollinated by one perfect stamen. The fruits set seed, which I subsequently grew.

GRAMINEÆ.—*Hordeum murinum*, as far as I am aware, is always cleistogamous. The filaments do not seem ever to escape from the closed glumes, but remain doubled or twisted back, so that the anthers lie in contact with the stigmas (fig. 57).

* "Fertilisation of Orchids," p. 106, 1st ed.

The preceding will be sufficient to prove that self-fertilisation is a great and wide-spread fact in the vegetable world; and that, so far as the plants themselves are concerned, they show no features which imply degeneracy of any kind. They are very abundant. Nearly all of our "most troublesome weeds" are habitually self-fertilising, and show no signs of extinction whatever. Their power of propagation is simply enormous.

Now arises the question as to what is the right interpretation of this fact. My idea is, that self-fertilisation is the legitimate or primeval condition of plants; that for the sole end of plant-life—propagation—extraneous aid is quite superfluous; and that plants have become adapted to insects, is, so to say, an accidental circumstance of no value at all, so far as the securing of a sufficient supply of seed is concerned; that the notion that plants *must* be crossed to be kept up is a wrong surmise, which is not really at all borne out even by Mr. Darwin's experiments.

Let us briefly review those results. One plant alone was cultivated for several years, *Ipomœa purpurea*, or the so-called *Convolvulus major*. On turning to page 53 of his work on "Cross and Self-fertilisation of Plants," the respective heights of the crossed and self-fertilised individuals will be seen exhibited in a tabular form. There is no steady increase in favour of the intercrossed, but a series of *maxima* and *minima*. On the other hand, *there is a steady decline in the heights of the crossed* when a series of averages are taken for every successive three years, a fact which Mr. Darwin does not seem to have observed. Although the actual heights of the intercrossed plants were in every year greater than those of the self-fertilised, yet the ratios taken as above proposed are as follows: For the first three years as 100 : 74·3; for the second three years as 100 : 77·6; and for the third three as 100 : 81·6. The interpretation of this can only be that while "crossing" imparted a stimulus to vegetative vigour, *it is not permanent*, but at the above rate of decrease the crossed plants would have become lowered in height, and be equal to the self-fertilised in a few more generations.*

With *Mimulus luteus* a strong self-fertilising form arose under Mr. Darwin's cultivation, so that it was quite useless to continue the experiment after seven generations, as the self-fertilised form entirely surpassed the intercrossed.

As it was with the heights so was it with fertility. The advantages gained at first were not apparent after a few generations, and the self-fertilised, then, beat their opponents.†

* 100 is the assumed standard for the intercrossed; the ratios, therefore, appear to show a steady improvement in the self-fertilized.

† For arguments and statistics I must again refer the reader to my original paper (*l.c.*).

Mr. Darwin did not cultivate any other plants sufficiently long to enable one to test the results of the permanency of the effects of crossing; but what I wish to point out is that we must not confound permanent morphological characters obtained by crossing with any physiological benefit necessarily and much less permanently resulting from it. Mr. A. Knight's varieties of peas obtained by crossing may have retained their morphological characters by which they were known in the market for sixty or more years; but to imagine that their longevity was due to the fact of crossing, is an assumption based upon no proof whatever. Mr. Darwin's experiments appear to me to prove the exact contrary, for in no case does he show that the physiological effects are more than transitory, even when the offspring are fresh crossed every year; while, on the other hand, Mr. Knight's peas were actually propagated for sixty years by self-fertilisation alone.

The reader will now ask, "What, then, is the good of crossing at all?" I reply, as far as the sole object of plant-life is concerned—that is, an abundance of seed—that the species may survive in the struggle for life, *there is no good at all*, and that self-fertilisation is the best and most certain method. And if it be asked why there are so many adaptations to insects, I reply that I believe it was an inevitable response to the irritation caused by the insects themselves. Moreover, insects often do more harm than good, when they discover that they can secure the honey by illegitimately perforating the corolla tube from without.

I believe that plants would never have had conspicuous perianths at all if insects had not visited them; but by causing a continual flow of nutrition to the external whorls, in consequence of their sucking away the juices, hypertrophy has set in, and the result is that *Man*, but not the plant, has gained the benefit, for he can appreciate the innumerable beautiful forms, colours, and scents, which so many flowers now possess. This result, however, is occasionally *at a sacrifice to the plant itself*, in that it has in some cases, but in the minority, lost the power of self-fertilisation; and, consequently, if a plant be an annual or biennial, and be not visited, it must succumb in the struggle for life, and so perish altogether. Self-fertilising plants are mostly annuals and small; both features being of great advantage in maintaining their continued existence. The rapidity of maturation and shedding of seed is perfectly astounding, generation after generation being produced in a few weeks, while the absolute amount of seeds produced is quite incalculable.

Lastly, the self-fertilised plants are the only ones, as a rule, which are cosmopolitan. I must refer the reader to my paper in the "Linnæan Transactions" for detailed lists of localities

where our weeds, such as Chickweed, Shepherd's-purse, *Lepidium ruderale*, *Malva rotundifolia*, *Solanum nigrum*, etc., etc., have established themselves; and the inference I draw is, that assuming other plants to have travelled with them, those which were entirely dependent upon insects have perished, as they were not visited; while those that were independent, as being capable of self-fertilisation, were the best fitted to survive in the struggle for life.

The conclusion I have arrived at is that self-fertilisation is the aim of plant-life, so far as propagation is concerned; that the existence of sexes enables a plant to diffuse itself by the production of independent offspring (seeds) far more readily and abundantly than by bulbs, and other vegetable offshoots; and that the chance of crossing is thus secured which induces variation in the offspring with greater rapidity than would spontaneously take place under self-fertilisation alone.

The cross may bring with it some new physiological peculiarities, which impart a temporary stimulus to vegetative vigour; but there is nothing to prove that this effect is of permanent value. I believe that by the local irritation induced by insects, all the vast diversity of beauty of form, and marvellous adaptations have been effected; but that this last, though vastly enhancing nature from the human point of view, is of no real value, but is often a detriment to the plant itself. Hence I regard self-fertilisation as being proved to be the best condition in plant-life, to enable a species to maintain its existence in the great struggle for life in the world.

DESCRIPTION OF PLATE I.

FIG. 1. Pistil of *Capsella Bursa-pastoris* to show the capitate form of stigma characteristic of self-fertilising *Cruciferæ*.

„ 2. The stigmas of *Fumaria officinalis;* one of them is covered with pollen-grains.

„ 3. One of the groups of anthers, which form a three-sided chamber in which the horn-like stigmas lie and are thus directly pollinated.

„ 4. Bud of a cleistogamous Violet with the calyx removed, from a strong-growing garden plant.

„ 5. A spurred petal from another bud.

„ 6. A stamen retaining the nectariferous appendage, from the same.

„ 7. Pistil from the same, with curved style.

„ 8. Rudimentary petals of a cleistogamous bud of a wild form of Viole[t].

„ 9. Stamen from same.

„ 10. Pistil with the anthers coherent above, having been detached and elevated by the swelling of the ovary.

„ 11. Pistil with anthers removed.

FIG. 12. *Viola tricolor*. The corolla has withered, so that the spurred petal has pressed the pollen into the orifice, and has remained clinging to it. Both the petal and stamens have become elevated by the growth of the ovary.

„ 13. This represents the style and globular stigmatic "head" of a self-fertilising form of *V. tricolor* var. *arvensis*, in which the placentiferous tissue had grown up like a pillar and protruded from the orifice in the form of a knob. Pollen tubes were penetrating the centre of the pillar in abundance.

„ 14. Vertical section of the preceding.

„ 15. Another self-fertilising adaptation, in which the placenta had grown over the "lip," and was prolonged into a kind of tongue which thus "licked" up the pollen from the spurred petal.

„ 16. Apex of pistil and stamens of *Polygala vulgaris*. The anthers are emptying themselves of pollen into the spoon-shaped extremity of the style.

„ 17 (after Hildebrand). The stigma is seen to become pollinated by bending back into the pollen.

„ 18. A form in which the anthers are on a level with the stigma, into which abundance of pollen-tubes had penetrated.

„ 19. A self-fertilising bud of *Spergula arvensis* (Jan. 1874).

„ 20. Same with calyx and corolla removed.

„ 21. A flower of Chickweed. This, as also the *Spergula*, has the number of stamens reduced to three.

„ 22. The stigmas of *Malva rotundifolia* represented as recurved amongst the anthers, and becoming self-fertilised.

„ 23. Stamens and pistil of *Linum catharticum*.

„ 24. Stamens and stigmas of *Pelargonium zonale*. The stigmas are recurved amongst the anthers and becoming pollinated by them.

„ 25. Cleistogamous flower-bud of *Oxalis Acetosella*.

„ 26. Calyptriform corolla of the same.

„ 27. Anthers of same united together by filamentous processes. (It is not quite clear what these are, but probably *not* pollen-tubes.)

„ 28. Pistil of same, with anthers of two of the latter stamens in contact with the short stigmas. The lower anthers are partly aborted, two filaments only represented.

„ 29. Cleistogamous flower-bud of *Impatiens fulva*.

„ 30. Same with calyx and corolla partly detached from the pistil (after Bennett).

„ 31. Stamens of same.

„ 32. Stamens and pistil of small-flowered leguminous plant, such as *Medicago denticulata*, the ten anthers being clustered round the stigma, both maturing together.

„ 33. A stamen and a flower of *Agrimonia*, the corolla removed, with stamens incurved, some time after expansion.

„ 34. First stage of *Circæa lutetiana* on expansion. The anthers are close to the stigma.

„ 35. The second stage of the same, the anthers now spread away. The stigma having been pollinated, is drawn to one side by mechanical adhesion to the anther.

FIG. 36. Anther-tube and recurved stigmas, characteristic of the tribe *Cichoraceæ* of *Compositæ*.

„ 37. Cleistogamous flower-bud of *Lamium amplexicaule*.

„ 38. Vertical section of the same, showing the stigmas lying between the anthers.

„ 39. The pistil removed to show how the style has become bent under constriction of the corolla.

„ 40. Corolla of *Salvia clandestina*. The essential organs are quite invisible.

„ 41. Stamens of the same. The anthers stand edgeways, so that the lines of dehiscence face each other.

„ 42. The styles removed. In one, the very long stigmas are unrolled artificially.

„ 43. Stamens and stigmas of *Prunella vulgaris*. The posterior branch is being pollinated.

„ 44. Two stamens and pistil of *Rhinanthus Crista-galli* var. *major*, adapted for intercrossing by the stigma being protruded.

„ 45. Two stamens and pistil of same, var. *minor*, adapted for self-fertilisation by the stigma being reflexed.

„ 46. Stamens and pistil of the garden variety of *Calceolaria*.

„ 47. Homomorphic form of Primrose, which produced plenty of good seed.

„ 48. Flower of *Glaux maritima*, with the stigma recurved to secure self-fertilisation.

„ 49. Side view, and

„ 50. Front view of the pistil of *Pinguicula lusitanica*.

„ 51. Pistil and the two stamens of same. The stigma is inserted into the anther-cells.

„ 52. Two stamens and one carpel of *Alisma Plantago*. One stamen is spreading as for intercrossing; the other is reflexed, a subsequent condition, for self-fertilisation.

„ 53. *Ophrys apifera*, showing the pollinia falling from the anther-cells in the position for striking against the stigmatic surface.

„ 54. Pollinium removed, showing the bend in the caulicle.

„ 55. Stigma and pollinium of *Cephalanthera*.

„ 56. Self-fertilising flower-bud of *Tradescantia erecta*. The withered corolla is partially removed, the calyx not being represented. The stigma is being pollinated by the one perfect anther. The rest are aborted.

57. Stamens and pistil of *Hordeum murinum* as they occur in the permanently closed florets.

THE OLDEST MOUNTAIN IN ENGLAND.

By C. Callaway, M.A., D.Sc. Lond., F.G.S.

IN determining the antiquity of a mountain, we have to ascertain either the period at which the mineral matter of which it is composed was brought together, or the epoch in which the mass was lifted above the surface of the ocean. The Swiss Alps, for example, are largely composed of strata deposited in several epochs from the Carboniferous upwards, but these mineral masses were not upheaved until the comparatively recent period of the Eocene Tertiary. Or to take an illustration nearer at hand. The Cotswold Hills are mainly composed of oolitic limestone, which was once a muddy sea-bottom of the Jurassic epoch, but as a mountain range they did not exist before Tertiary times. If we regard the period of their origin as a mineral mass, we shall call them Jurassic; but if we consider only the period of their elevation, we shall describe them as Tertiary.

If we regard only the epoch of the *mineral* origin of a mountain, the Malvern Hills have probably the best claim to priority. They consist of schistose rocks, which were deposited as sand and clay in an ocean which probably dates as far back from the Cambrian epoch as the Cambrian epoch dates from ours. Whether or not we accept Dr. Holl's determination of their Laurentian age, it is certain that the Cambrian strata, the oldest rocks in Britain which contain the remains of organic life, succeeded them at an immense interval of time. It is possible that some portion of the Malvern ridge stood above the waves in Pre-Cambrian times, but proof of such elevation is wanting. It is clear, however, that the Malvern Hills existed in part before the close of the Cambrian epoch. For details on these points reference may be made to Phillips's "Geology of Oxford and the Valley of the Thames," and to a paper by Dr. Holl in the "Quart. Journ. Geol. Soc.," Feb., 1865.

The hill for which is claimed the title of "Father of English mountains" is the Wrekin, which stood above the ocean in Pre-Cambrian times, and had attained the dignity of a mountain

early in the Silurian epoch. This hill is only one of a chain twenty miles long, but it is selected as the one most carefully studied by the writer.

The Wrekin is about two miles south-west of the town of Wellington. It rises sharply up from the Triassic plain of North Shropshire, and stands out as the advanced guard of the numerous ridges which intersect the southern half of the county. But it is six or seven miles distant from the main groups, and its isolation gives it great prominence. It is only 1,320 feet in height, but it is said to be the highest mountain in Europe for the circumference of its base. The range of which it is the most conspicuous elevation is three miles in length, trending north-east and south-west, and is cut into three separate masses by two deep and narrow gorges. The Wrekin proper is one mile and three quarters long, and about half a mile in breadth at the base. Its shape is peculiarly graceful. Viewed from almost every point its outline forms an unbroken curve. From the north-west it appears like a quarter moon resting on the earth with its convexity upwards. From the south-west it presents the outline of a perfectly symmetrical arch. The legend runs that this arch was piled up by an industrious giant. Science tells us that it was originally thrust up between two parallel dislocations or faults as a gigantic wedge, and was subsequently rounded into its present elegant form by the busy fingers of frost, carbonic acid, and rain, working unceasingly through immeasurable ages.

No authentic account of the origin of the Wrekin has yet been published. A pseudo-scientific description from a local guide-book of the birth of the mountain is little less mythical than the legend of the giant's arch. The reader is gravely informed that "when the struggling gases below the Silurian ocean made an effort to be free, a power of indescribable force shook the earth, upheaving the ocean bed and throwing up precipitous hills above the waves; and so, amidst boiling waters, hissing steam, and exploding gases, the Wrekin and its adjacent hills rose to their present elevation."

The account of the structure of the Wrekin in Murchison's "Silurian System" is more rational, but it is equally erroneous. The mountain is described as a mass of disruptive greenstone forced up into the midst of Caradoc sandstone and shale, and altering the sandstone into the hard white crystalline rock called quartzite. This account of the Wrekin is endorsed by the Geological Survey, whose map and sections of the district were published during the time Murchison was Director General. According to this hypothesis, the mountain is necessarily younger than the Lower Silurian strata on its flanks. But no terms could more unfitly describe it than "disruptive green-

stone." Greenstone is a dark crystalline volcanic rock, poor in silica, and characterised by the large proportion of iron, magnesia, and lime contained in it. But the Wrekin is chiefly composed of rocks of a pink, red, or grey colour, rich in silica, and deficient or wanting in iron, lime, and magnesia. This rock, so far from being disruptive, was deposited in beds not only before the Caradoc epoch, but long anterior to the much older Cambrian strata. Let us examine these points in more detail.

In modern volcanic eruptions the ejected matter is either felspathic or augitic. The latter is dark coloured, and contains a large proportion of the bases named as characterising greenstone; indeed, we may consider augitic lavas as the modern representatives of the ancient greenstones. The felspathic ejections of volcanoes are either molten as lava-flows, or fragmental as ashes and breccias. They are generally lighter in colour, and, containing less iron, are not so heavy. No essential distinction can be made between ancient and modern igneous rocks. Both are the result of the same heat forces. In all ages volcanic action has been ejecting ashes, pouring forth floods of molten lava, and injecting into fissures of the crust melted matter which cannot reach the surface as lava. Beds of ashes, layers of lava, amorphous masses of molten rock, the common products of Etna and Vesuvius, were formed in all geological epochs. The separation of igneous rocks into volcanic or modern, and plutonic or ancient, is arbitrary and unphilosophical, and is furthermore calculated to mislead the student by suggesting that plutonic rocks were formed under mysterious and unknown conditions. Mr. Allport has shown, by both chemical and microscopic analysis, that the rocks of the Wrekin are identical with the modern ejectamenta of volcanoes. Certain changes have taken place during the lapse of ages by the action of infiltrated atmospheric waters, but it cannot be doubted that originally the volcanic rocks of the Wrekin were essentially the same in composition and in mode of formation as the materials of modern volcanoes. This is one of the most important generalisations of recent years, and it derives additional interest from the discovery by the writer of the Pre-Cambrian age of the Wrekin. Mr. Allport carried back the period of existing volcanic action to what he considered Silurian times. In this paper it will be shown that in times perhaps more remote from the Silurian than the Silurian is from ours, the volcanoes of Shropshire ejected lava and ashes undistinguishable from the products of existing craters. The fire forces may have been more energetic, but they produced the same results in the same way. The volcanoes which in Pre-Cambrian times covered with their lavas and ashes the area now called South Shropshire were

doubtless more quickly thrown up, and it is not unlikely grew to vaster proportions, than the average of existing volcanic mountains, but there is no essential difference in their physical and mineral constitution.

It must not be supposed that the Wrekin represents a volcano such as Etna or Vesuvius, or even such dilapidated cones as are dotted over the Miocene region of Central France. In the Wrekin there is no trace of cone-structure whatever. The mountain is bedded like the limestones and shales of Wenlock Edge, or the Chalk strata of Sussex. Even in volcanoes of Tertiary age, denudation has often left nothing remaining but the amorphous roots or foundations of what was once a lofty and symmetrical cone; and in regard to volcanic mountains of an epoch to which the Tertiary periods are but as yesterday, we have infinitely less reason to expect any traces of the original cone-structure.

The Wrekin is chiefly composed of a great bedded series consisting of alternations of felstones (felspathic lavas) and felspathic tuffs. At the north-east end are beds of volcanic breccia, alternating with fine-grained ashes. Underlying these are pink and white felstones, displaying a distinct banded structure, due, it is supposed, to the flowing motion of the rock in its original form as molten lava. Towards the summit of the mountain we come again to a hard pink breccia; and at the summit the rock is a compact purple felstone. On the south-west flank of the hill is another exposure of tuff. The spur called Primrose Hill, the south-west extremity of the range, is composed of a brick-red felstone, passing, by the addition of quartz and a little mica, into an imperfect granite.

These lavas and tuffs have a distinct dip to the north, or a little to the west of north, at an average angle of about 45°. The direction of the ridge being N.E. and S.W., and the strike of the beds being about east and west, it will be seen that the beds strike across the ridge at an acute angle, so that the direction of the range and the shape of the mountain are not materially determined, as is commonly the case in mountains composed of ordinary stratified rocks, by the strike and dip of the beds. A section drawn at right angles across the ridge represents the strata with a seeming dip to the north-west at a low angle. This will be readily understood when it is remembered that such a section would cut the direction of true dip at an acute angle. This discordance of the strike of the strata with the strike of the range will remind geologists of the structure of the Malvern Hills, in which schistose rocks strike north-west and south-east across a north and south ridge.

It has been shown that the volcanic rocks of the Wrekin are as clearly stratified as the limestones and shales of Wenlock

Edge; but it must not be supposed that the beds are so regular and persistent. The limestone of Wenlock Edge is continuous and unbroken for nearly twenty miles; and in the United States, the Corniferous Limestone extends from the Hudson to the Mississippi. But the lavas and ashes of the Wrekin form lenticular masses rather than regular beds. It is rarely possible to follow a stratum along its line of outcrop for many hundreds of yards. The breccias especially thin out very rapidly. But this is precisely what the analogies of modern volcanic action would lead us to expect. The layers of lava and tuff of which a cone is composed, and by which it is surrounded, thin out rapidly towards the circumference of the volcano, and the coarser the material the less persistent is the bedding. Volcanic matter ejected under the sea, as was the case with some, if not all, of the Wrekin beds, is deposited more evenly and over a much wider area; but the principle is the same.

Associated with the stratified rocks of which the mountain is chiefly composed, are certain masses of much less antiquity, to which the term "greenstone" may appropriately be applied. In ascending the Wrekin from the north-east end, we notice in the centre of the ridge, about midway between the north-east end and the summit, a bare rounded hump, which on examination proves to be a mass of greenish dolerite or basalt, which has been forced up when in a molten state through the midst of the older bedded series, disturbing their strike, and apparently, in one place, reversing their dip. From this disruptive boss proceed several vertical dykes of basalt, three of which can be well seen at the north-east end of the mountain, striking towards the central mass. This basaltic rock was probably erupted in newer Palæozoic times, but its exact age does not affect our present inquiry. The Wrekin existed as a distinct elevation many epochs before the dolerite boss and dykes were formed, and their bulk is unimportant compared with the mass of the mountain.

The Wrekin, though mainly, is not exclusively composed of igneous rocks. Buttressing the ridge on both sides are certain beds of quartz rock, about two hundred feet thick, dipping away from the axis at an average angle of 45°. They also lap round the ends, and their dip is, in every case, away from the mountain. This quartzite evidently once formed a continuous bed of sandstone, and, judging from the dip of the pre-existing volcanic strata, was deposited unconformably upon them. Then an upheaving force produced two cracks in the rigid crust of bedded felspathic rock, and pushed up between the cracks a narrow wedge, which, in its turn, forced a way up through the sandstone, tilting it off on all sides, and crushing up its lower surface into a breccia.

Previous to this elevation, or perhaps subsequently, the sandstone was converted into quartzite.

On its north-west side, the Wrekin, with its overlying quartz rocks, is bounded by a fault separating it from the Bunter sandstone, the lowermost division of the Triassic rocks of North Shropshire. But on the south-east the quartzite is succeeded by green sandstones, formerly supposed to be of Caradoc age, which the writer has demonstrated to be the true Hollybush Sandstone of the Malvern Hills.* Not only does this rock contain two common Malvern fossils, *Kutorgina cingulata and Serpulites fistula*; but it is precisely similar to the Malvern sandstone in lithological and mineral characters. Outside of this band of Hollybush Sandstone is a parallel zone of shales, which have been shown in the same paper † to be of Tremadoc age. The quartzite, the Hollybush Sandstone, and the Tremadoc Shales are separated from each other by faults, and, from the structure of the whole country, it is clear that they were successively deposited at distant intervals. The Tremadoc Shales are Upper Cambrian; the Hollybush Sandstones are probably Lower Cambrian; and the quartzite has been shown by the writer ‡ to be Pre-Cambrian.

It was intimated early in this paper that some part of the Wrekin rose above the waves in one of the Pre-Cambrian epochs. In the lower part of the quartzite, on the south-east side of the mountain, small pebbles of decomposed felstone, showing the characteristic banding of some of the Wrekin rocks, are imbedded. Besides this, the quartzite is wanting under the summit of the hill on both sides, so that the summit was probably dry land during the deposition of the sandstone. These facts seem to point to the following sequence of events. The Pre-Cambrian sandstone (now quartzite) was deposited round an island of felspathic rocks, the partial denudation of which supplied the pebbles. Subsequently, the wedge-like upthrust previously described took place, and a north-east and south-west ridge of felspathic rock, set in a framework of sandstone or quartzite, rose above the waves of the Lower-Palæozoic Sea.

That rocks of the Wrekin chain formed dry land in times preceding the Cambrian will be further evident from the following considerations. In a low elevation, about two miles west of the Wrekin, is a good exposure of Pre-Cambrian rocks with their usual east and west strike. These ancient strata here contain a band of well-marked conglomerate, consisting of rounded pebbles of quartz, mica-schist, pink felstone, and an imperfect granite.

* "Quart. Journ. Geol. Soc." vol. xxxiii. p. 662.

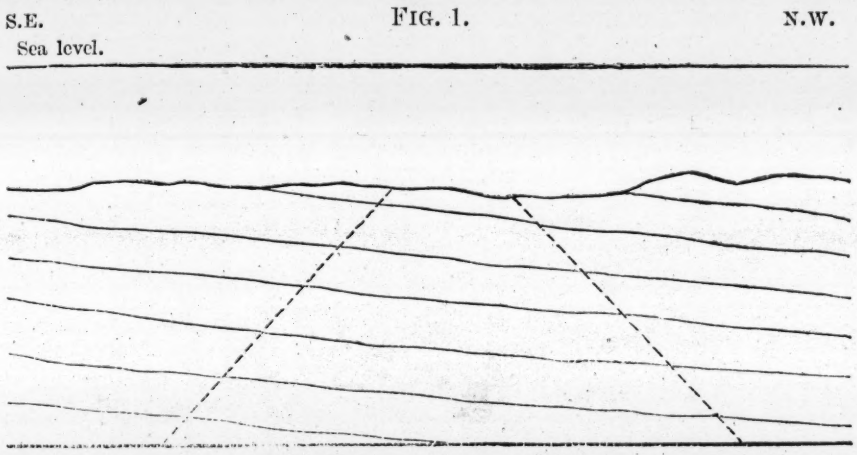
† Ibid. pp. 657–662.

‡ Ibid. vol. xxxiv. p. 754.

The felspar rock and the granite closely resemble some of the Wrekin felstones and bastard granites; but, however this may be, it is certain that the conglomerate, being a shore deposit, was derived from neighbouring land. It is clear, then, that some portion of the Wrekin mass—not necessarily, though very probably, the actual Wrekin wedge—was elevated above the Pre-Cambrian ocean.

Figs. 1 & 2 are an attempt to represent two stages in the Pre-Cambrian history of the Wrekin.

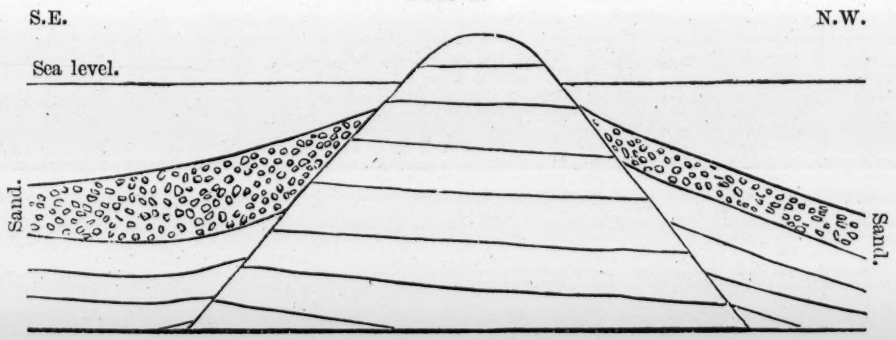
FIG. 1.



THE WREKIN—FIRST STAGE.

Beds of tuff and lava have been formed by volcanic eruption. They have been tilted up with a considerable dip to the north, which is represented as a slight dip to the north-west, the section being taken at right angles across the present axis of the hill. They have since suffered considerable denudation, and now form the bottom of the Pre-Cambrian sea. The Wrekin commences an independent existence by its separation from the main mass by two parallel faults, represented by the dotted lines.

FIG. 2.



THE WREKIN—SECOND STAGE.

The wedge is now thrust up above the level of the waves, disturbing the adjoining beds in its upward motion. A portion of the ridge forms an island, which furnishes pebbles to the sands (afterwards quartzite) which are accumulating round its margin.

Whether or not the Wrekin stood above the sea in the Cambrian epoch is difficult to determine. In the Lower Cambrian

strata of Haughmond Hill, near Shrewsbury, the "busky hill" of Shakspere's *Henry IV.* is a great bed of conglomerate, coloured "greenstone" on the map of the Geological Survey. The pebbles of which this rock is mainly composed are of reddish felstone, resembling some of the Wrekin felstones. This conglomerate was certainly derived from land of a similar mineral structure to the Wrekin, and it is only six miles distant from that elevation; but it would be somewhat rash to assume that the Wrekin was the only mass from which the felstone pebbles could have been derived. There is, however, no doubt that Pre-Cambrian land existed in Lower Cambrian times somewhere in the neighbourhood of the Wrekin.

Emerging from the dimness of these ancient epochs, we come into the clearer light of the Silurian period. The dawn of that age shone upon the Wrekin rising sharp and lofty above the waves. During the Arenig and Llandeilo periods, the forces of the atmosphere were incessantly employed in reducing its size and rounding its outlines. In a south-westerly direction, its base, consisting of a framework of Upper Cambrian shales, extended several miles. Towards the Caradoc epoch, the Wrekin island began to sink, and was lapped round by Lower Caradoc sandstones and conglomerates. The depression still went on, successive strata of the Caradoc formation overlapping each other on to the sloping Cambrian margin. In the Lower Llandovery period the motion was reversed, and no strata were deposited round the island; but in Upper Llandovery times depression was resumed, and was continued till the Pentamerus Limestone and its associated conglomerate margined the very flanks of the Wrekin itself, and the succeeding deposits of the Wenlock and Ludlow periods probably surrounded and buried the greater part or the whole of the mountain.

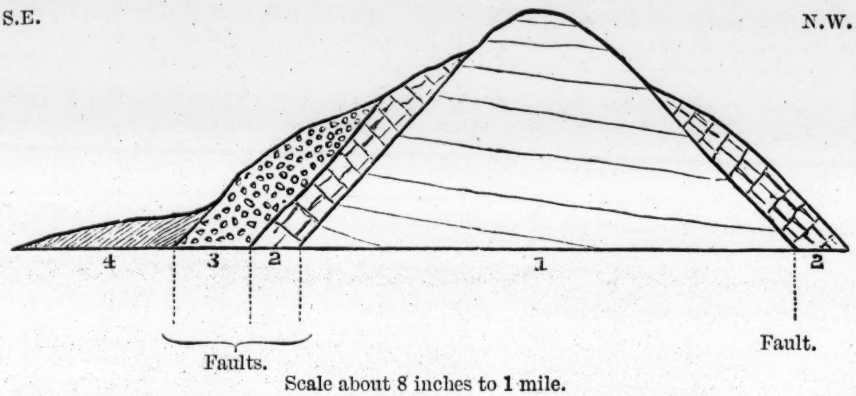
During the period of the Old Red Sandstone, the Wrekin rose again above the ocean, while the forces of the sea and air were actively at work in stripping off the superincumbent layers of Upper Silurian rock, and once more exposing the buried mountain to the light of day.

Early in the Carboniferous epoch, depression once more commenced, and sandstones were deposited round the lower slopes of the Wrekin, succeeded by coral-reefs and banks of shells. Then the surrounding sea gradually shallowed, gave place to low swampy land covered with ferns, lycopods, and sigillariæ, and inhabited by insects. These land surfaces, by oscillations of the crust, alternated with clays containing marine shells and king-crabs.

The later part of this period was marked by active vulcanism. Numerous volcanic cones were dotted over the West-Midland counties. The Rowley Hills, near Dudley, and the Clee Hills, in

South Shropshire, are good instances of the remnants of these eruptions. Immediately to the south-east of the Wrekin, and forming a parallel ridge, is a great layer of dolerite, which had been intruded amongst the Lower Carboniferous rocks, and exposed by subsequent denudation. This mass has by some writers been lumped together with the ancient felspathic rocks of the Wrekin; but there is no reasonable doubt that it belongs

FIG. 3.



Scale about 8 inches to 1 mile.

THE WREKIN—ADVANCED STAGE.

Fig. 3 represents the Wrekin in its present form. The wedge has been further uplifted, tilting up on its flanks the beds of Pre-Cambrian sandstone (now quartzite). On the south-east side are also seen two sub-formations of Cambrian rock. In early Silurian times, the general relations of the several groups must have been as here represented; though the volcanic nucleus was doubtless buried under masses of Cambrian strata. The superincumbent envelope must have been removed, and the volcanic wedge exposed to the light of day, before the Silurian period had reached its meridian.

1. Bedded Pre-Cambrian volcanic tuff, dipping north.
2. Quartzite.
3. Hollybush Sandstone.
4. Shineton Shales (Tremadoc).

to the same eruptive period as the Rowley and Clee Hills. The disruptive boss and dykes previously described as occurring at the north-east end of the Wrekin, are probably of the same epoch. The boss may, indeed, be the consolidated remains of the molten rock which filled a pipe or neck, and which subsequently intruded itself between the adjacent Carboniferous strata, though the two masses are now isolated by the denudation of the intervening valley.

In the period of the New Red Sandstone (Permian and Trias) the depression was continued, and the Wrekin was more or less buried under deposits of red sandstone, accumulated, in all probability, in inland seas or lakes. These sandstones may subsequently have been covered in by the marine strata of the Jurassic and Cretaceous epochs.

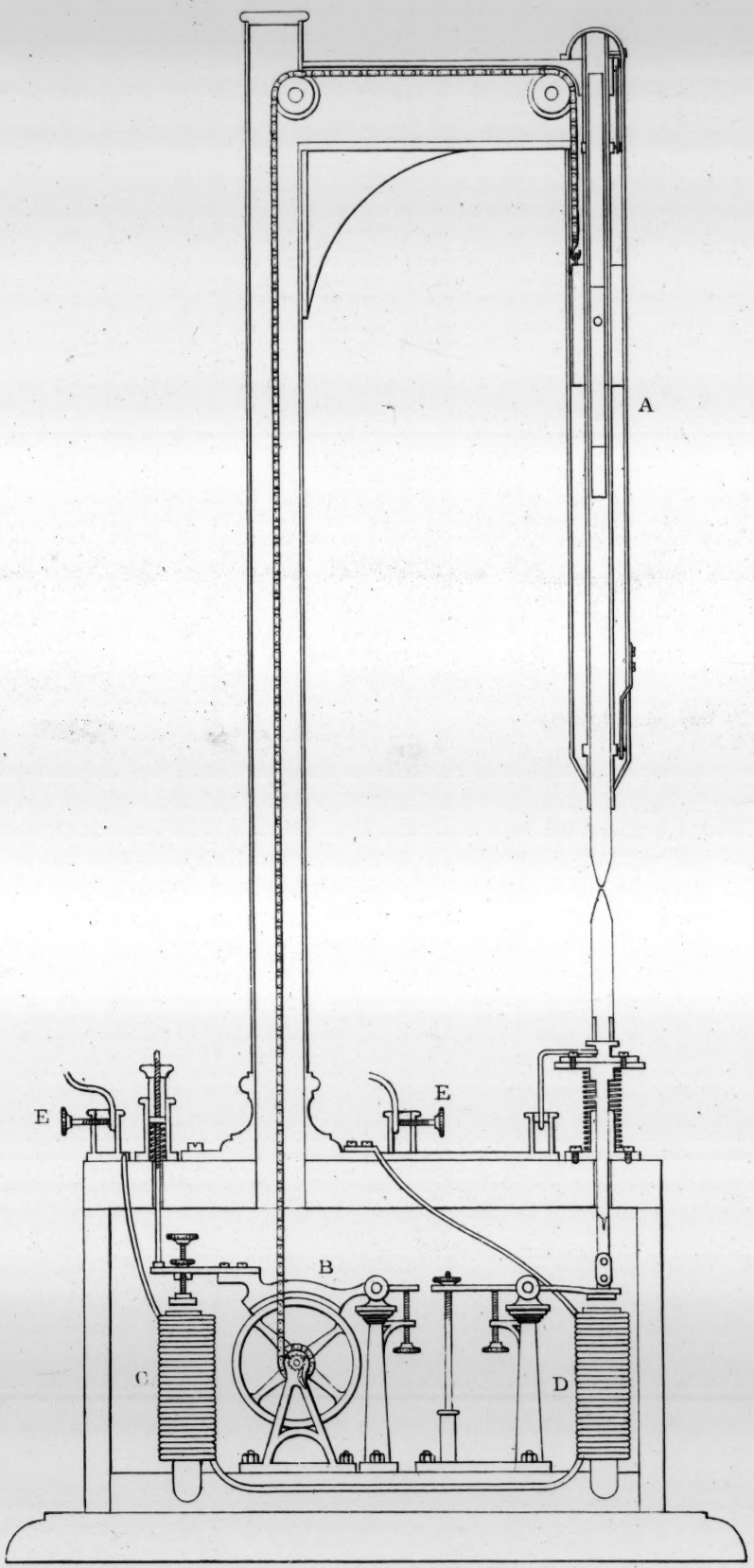
In some period succeeding the Trias, certainly later than the Lias, probably at the close of the Mesozoic, great dislocations took place in a north-east and south-west direction. In very early times lines of fracture had been established at the base of the Wrekin on each side. Between two of these faults the Wrekin had originally been thrust up as a solid wedge of the earth's crust. The disturbing forces had, during successive epochs, in the manner described, been acting along these lines of weakness. The wedge had been alternately uplifted and depressed, and, in some cases, large areas surrounding the lines of more violent movement had, to a greater or less degree, shared in the motion. These movements were renewed, with great violence, at the close of the Mesozoic epoch. Triassic sandstones, as the result of these dislocations, now lie faulted against the base of the Wrekin, just as they lie along the eastern flank of the Malvern Hills; and, farther to the south-west, Triassic, Permian, and Carboniferous strata are in succession thrown down against Cambrian and Silurian rocks.

During successive Tertiary ages, the Wrekin was gradually disincumbered of its enclosing Mesozoic envelope by the united action of marine and sub-aerial denudation.

In the Glacial epoch, the mountain again suffered submergence, partial or entire. Marine sands, containing boreal shells, are found on its lower slopes, and testify to the presence of the ocean. Subsequently to the formation of these deposits, icebergs from the north, laden with boulders of granite and felsite, were stranded against the flanks of the mountain, and deposited their rocky burdens. It is also probable that the Wrekin was wholly or in part buried beneath continental ice during some part of this period.

Last of all the sea retired, and the Wrekin made its final emergence from the waves. No material change has since then taken place; but the atmospheric forces have been and are still at work. Frost, with its million wedges in every square foot of exposed surface, reduces the hardest felstone to powder. Carbonic acid, dissolved in rain-water, penetrates the felspathic rock, dissolves out the alkaline ingredients, and produces gradual decay. Finally, the falling rain washes down the particles loosened by frost or softened by decomposition, and the streams that drain the mountain deposit them on the lower ground, or carry them into the Severn. Thus this "Æonian hill," composed as it is of hard and intractable mineral matter, is being imperceptibly but inevitably reduced to powder, is "drawn down" by streams, and "sown" as

"The dust of continents to be."



Mintern Bros lith.

CHAPMAN'S ELECTRIC LAMP.

THE ELECTRIC LIGHT.

By W. H. STONE, M.D.

[Plate II.]

There has been no lack of material for the increased public interest which has of late been exhibited in the practical development of science; and the last instance differs materially from its forerunners in the great technical and everyday importance which it possesses. Even Telephones and Phonographs are far exceeded in popular attention by inventions which propose to revolutionize the system of general illumination, and to supersede coal-gas—a means of lighting which, though introduced within the memory of many still living, has become so familiar as to be unnoticed. There can be little doubt, moreover, that this popular excitement, though it may not have been intentionally stimulated by sensational announcements, has derived a peculiar zest and pungency from the financial results it has brought about. The great depreciation in shares of gas companies which followed Mr. Edison's announced, but still unexplained, discovery, not only set in motion the world of speculators and financiers, but led the consumer at large to hope for partial or complete emancipation from one of his old tyrants, and for the substitution of an immensely superior method of lighting.

And yet the Electric Light is, strictly speaking, no new subject. Produced by Sir Humphry Davy, at the beginning of the century, from his large battery of 3,000 cells, it has been ever since an essential of the laboratory, and has for many years been occasionally exhibited in public.

A great impetus was, however, given to its study by Faraday's discovery, in 1831, of the induction of currents by magnets, thus dispensing with the expensive and troublesome battery.

Machines of this nature were constructed in 1849 by Holmes, and by the Alliance Company of Paris, which have worked satisfactorily at the South Foreland, Cape Grisnez, and several other lighthouses, for many years.

The current is here produced from armatures rotating in front of fixed permanent magnets, arranged symmetrically round

them. The instrument is large, cumbrous, and expensive. The permanent magnets are liable in course of time to weaken, and, indeed, the apparatus has hitherto only been utilized for the single beam of the lighthouse.

The system has, however, been revived in a modified form quite recently by Mons. de Meritens.

A great advance was made on this stage by Dr. Siemens, Sir C. Wheatstone, and Mr. Varley, in 1867. It was shown, that if an induction coil be made to revolve in front of a soft iron electro-magnet, instead of before a permanent magnet, as in the earlier machines, the small amount of residual magnetism always latent in the iron, especially if it has once been magnetized, causes feeble currents to be induced in the coil; if these currents, or a portion of them, be sent round the iron magnet, into the wire surrounding it, the magnetization is increased. This again produces a proportionate increase in the induced currents in the coil; thus by a series of successive mutual actions, intense magnetization and very powerful currents are produced. Machines constructed upon this principle of reaction have been termed "dynamo-electric" machines, as indicating that dynamical force is converted into electricity. For the older form, where permanent magnets are employed, the term "magneto-electric" has been retained; their power being limited by the strength of magnetization of the permanent magnets made use of. This discovery, by adding considerably to the power of electric machines, led to a corresponding diminution in their bulk, and also in their cost. Almost, if not quite all subsequent machines are "dynamo-electric" in construction, and based on the principle of mutual reaction.*

Those of this kind best known in this country are the Siemens and Gramme machines.

In the former the armature or induction bobbin, on Dr. Siemens' principle, has its enveloping wire wound lengthwise, and parallel to the axis of rotation; it rotates between semi-circular prolongations of large flat electro-magnets placed on either side of it; their north pole being immediately above, the south pole immediately below the axis of the bobbin. It is commonly made of three sizes, the smallest costing £70, consuming 2-horse power to drive it, and giving, with 850 revolutions per minute, an illuminating power of 1,200 candles. The illuminating power of the two larger machines is of 6,000 and 14,000 candles respectively.

The Gramme machine is composed of an induction coil having a ring or cylinder of iron revolving between a pair of electro-magnets. The ring is wound with a number of transverse circles

* From a paper "On the Present State of Electric Lighting," read before the Brit. Assoc. in Dublin by J. M. Shoolbred, B.A., &c.

of wire, each of which when under the inductive influence is tapped by two brushes at a tangent to a circular commutator placed on the shaft, and carrying off the electricity in one continuous direction. It is also made in three sizes, costing respectively £70, £100, and £300, giving the light of 2,000, 6,000, and 15,000 candles.

Hitherto the subject has been considered in regard to single lights; but an important advance consists in securing the divisibility of the current so as to produce a number of lights instead of one. This object has been sought for for the last twenty years, but only practically solved by the Lontin and the Jablochkoff-Gramme systems. Both these work with currents not continuous, but in alternate directions. Indeed, the "candle" of M. Jablochkoff requires this as an essential condition to produce the equal combustion of the two parallel carbons. The Gramme machines have been therefore so modified as to meet this necessity.

Mons. Lontin works on another line. He has designed two machines instead of one. The former is termed the generator, the latter the divider.

The generator consists of a horse-shoe electro-magnet, between the poles of which rotates a coil formed in a star-like shape, of which the projecting arms are wound with wire. A series of these stars is arranged obliquely along the rotating shaft, so as to obviate any abrupt break in the inductive action. Two rubbing contacts collect the positive and negative currents, carrying them through the fixed magnet and so to the second machine.

This, the "divider," has a shaft carrying a series of larger stars with more radial electro-magnets, into which the currents from the generator are passed, so that they remain in a state of magnetic saturation.

Each star revolves in a wrought-iron cylinder, studded on its inner surface with short induction coils corresponding to the radii of the revolving star-wheel. These are coupled together so that their positive and negative poles are presented alternately to those in rotation. The result is a number of currents alternate in direction and equal in number to half the rotating spokes. The alternating current from each ring is collected separately on the exterior, and conveyed to a frame where the various elementary currents may be coupled in any desired number of circuits. The usual apparatus has twenty-four discs, which, by being coupled in pairs, produce twelve circuits, and can supply twelve separate lights, or can be all devoted to a single lamp.

The number of lights produced by one of these engines, which has a total illuminating power of 12,000 standard candles, at the Western Railway in Paris, varies from six to twelve. But as many as thirty have been supplied from a similar machine at the Lyons Railway Station.

For the convenience of M. Jablochkoff, Gramme has lately devised a similar instrument to that described above, except that the revolving drum has eight flat bars of iron wound lengthwise with wire placed radially, and supplied with a continuous current from Gramme's original generator. External and concentric to these are thirty-two coils, forming one or more alternating circuits at will. They are, in practice, coupled together so as to produce four. The intensity of the machine is that of 16,000 candles. As applied to lighting the Avenue de l'Opéra at Paris, by means of sixteen Jablochkoff candles, it is driven at the rate of 600 revolutions per minute, and is said to require an engine of 16-horse power.

Improved methods for the production of the current are far more recent than those adapted for its exhibition. Indeed, a mechanical lamp, hardly, if at all, inferior to those lately patented, dates back as far as April 1855. The specification of Mr. Henry Chapman, sealed on June 12th in that year, is before us, under the title of "An Improved Electro-mechanical Apparatus for Supplying and Adjusting the Electrodes used in the Production of the Electric Light." It works entirely by means of gravity, and dispenses with the costly and easily deranged clockwork of the Serrin, Foucault, and Siemens* lamps, which are all fitter for the physical laboratory than for general purposes. The comparative forgetfulness into which this excellent contrivance (see Plate II.) has fallen is probably due to the failure of the Electric Light and Colour Company which adopted it, and which proposed to compensate for the expense of the battery by producing salts of tin, and other metals useful in dyeing. In its day it was highly successful, and was proposed for use in reconnoitring the enemy's positions during the Crimean war.

Mr. Browning has long advertised several lamps acting on this simple but effective method, although he is entirely antici-

* In the Siemens automatic electric lamp the carbons are held vertically one over the other in the same relative position as in the Serrin lamp. Inside the lamp is a train of wheels gearing into racks formed, one on the stem of the lower and the other on the stem of the upper carbon holder. These wheels are so arranged that, assisted by gravity in the upper carbon holder, which is made sufficiently heavy, the points of the two carbons are caused to remain a precise and defined distance apart, which distance is constant during burning, and by means of which the shortening of the carbons by combustion is regularly followed up. A vane regulator or fly is used to control the rate of descent of the upper carbon and the corresponding ascent of the lower one. Should the carbons approach too closely they are separated by means of an electro-magnet which acts upon the end of an oscillating lever, which, during its periods of oscillation, causes the train of wheelwork to revolve in an opposite direction, and so to separate the carbons and to restore the voltaic arc.

pated by Mr. Chapman's patent, dated more than twenty-three years ago.

Among the more modern systems worthy of notice are the Rapieff, the Werdermann, and the Wallace-Farmer.

The last of these has been brought into prominent notice by its connection with Mr. Edison's still undisclosed discovery.* The Wallace-Farmer dynamo-electric machine divides American patronage with the Brush machine, just as the Siemens machine divides the English market with the Gramme. It comprises a dynamic machine as well as a special form of lamp. The lamp consists of a metal frame of brass, carrying two carbons in the form of slabs about nine inches long and three inches broad; the upper, or positive, being about half an inch thick; the lower, or negative, only about a quarter of an inch. The lower carbon is fixed to the bottom of the frame; the upper is carried by a cross-piece sliding up and down in side grooves. It can, therefore, be drawn apart from the lower to any adjusted distance, so as to determine the luminous arc. When the lamp is not in use, the upper carbon is let down into contact with the lower; but the act of putting on the current raises it one-eighth of an inch, and establishes the light by means of an ingenious mechanism. The arc either starts at the point of least resistance, or may be started by inserting a metal conductor for a moment between the two carbon edges. Once started, it subsists at that point until the consumption of carbon widens it to such a degree that a shorter and less resisting path for the current is to be found at a neighbouring point. In this way the arc travels slowly along the whole edge of the carbon, and when it reaches the other end, it turns and comes back again. The light can thus be maintained for one hundred hours without change of carbon, at a cost of about a penny per hour.

There can be no doubt that where exact stability in position of the luminous arc is not essential, this is a very cheap and simple method of producing the light. Messrs. Ladd & Co., who are the sole British agents, have exhibited it at their Shoreditch manufactory, terming it the "Workman's Lamp."

The Wallace-Farmer duplex dynamo-electric machine contains twenty-five coils set round the armature, each coil wound with four separate wires, the ends of which are brought up to an axial commutator, so that there are one hundred "makes and breaks" in one revolution. It can be worked up to 800 revolutions per minute, the power required to drive it being about one hundred revolutions per minute for each horse-power; each hundred, or each horse-power, being sufficient for one lamp. The armature, electro-magnets, and the work to be done are all in one circuit.

* "Telegraphic Journal," Nov. 7, 1878.

The Rapieff burner, now employed in the "Times" publishing office, shows great mechanical ingenuity, and presents the great advantage that it can be sustained for a whole night without change of carbons or attendance, and without alteration of intensity, as the current always passes through the same length of wick. This wick consists, not of two, but of four, pencils opposed to one another in pairs, the upper fed by the positive, the lower by the negative current. The four carbons form the figure X, except that the lower pair is set in a plane at right angles to the upper. As the points consume away, the carbons are made slowly to approach each other, so that the arc is always of the same width, and keeps its fixed position in space. They are directed towards each other over small pulleys by a counterpoise of about three pounds sliding down the stem of the instrument. In another form, the four carbons are all inclined to each other at a variable angle, and a cylinder of lime is supported over the light, which, becoming luminous, increases the illuminating effect by about 40 per cent. The Rapieff also places a safety apparatus under each regulator, which is simply an automatic arrangement for allowing the current to pass to the other lamps in the same circuit, should one lamp happen to become extinguished. There are six lamps in circuit at the "Times" office, but Mr. Rapieff has successfully exhibited as many as ten. The dynamic machines of Gramme are used as excitors.

The Werdermann light depends on a totally different principle. When in an electric lamp, electrodes having the same sectional area are used, the changes at the points between which the voltaic arc passes take place by a crater or hollow forming in the positive electrode which emits the light, the crater itself being heated by the current to white heat, and the surrounding part to redness. The negative electrode assumes the form of a cone, is only heated to redness, and emits scarcely any light. It is found, however, that an increase in the sectional area of the positive electrode diminishes the light emitted by that electrode; and if the increase be gradually continued, the light disappears entirely, while the heating effect upon the negative increases until it emits light. On the other hand, by increasing the sectional area of the negative electrode, the heating effect decreases proportionally to the increase of its area, until the heat almost entirely disappears, and the consequent consumption of that electrode is scarcely appreciable. The light given out by the positive electrode, on the contrary, increases in proportion to the difference between the sectional area of the two electrodes; and instead of a crater being formed in the positive carbon, this assumes the form of a cone such as before occurred to the negative. The greater the difference between the areas of the two carbons, the less is the length of the voltaic arc

between them, until at last the light is produced by carbons apparently in contact, and a small deposit of graphite is seen on the negative electrode. This deposit is about one-fourth the section of the positive carbon itself, and about one-eighth of an inch high.

Mr. Werdermann places the negative carbon, in the form of a disc, two inches in diameter and an inch thick, uppermost. It is clasped by a copper band attached to one terminal. The lower positive electrode is a small pencil of carbon, three millimetres in diameter, of any suitable length. It slides up vertically in a tube underneath the disc, projecting from it about three-quarters of an inch, this length being made incandescent when the current passes. It retains its point when burning. The carbons are kept in contact by chains passing over pulleys, and by a weight of about one and a half pounds pressing them gently into contact.

One of the most important elements in the economical consideration of the electric light is the motive power. The great objection which lay at the root of all earlier systems intended to utilise electricity either as a motive power, as in Jacobi's boat on the Neva, or as a source of light, was the expensive nature of the fuel required. The zinc consumed in the battery could only be produced at a cost which was practically prohibitory. The "Electric Light, Power, and Colour Company," started in 1855, endeavoured to evade this difficulty by using tin as the negative metal and utilising the refuse product for dyeing purposes. But this Company, though it brought out the excellent lamp of Mr. Chapman figured in the plate (Pl. II.), which contains the germ of many more recent patents, was commercially a failure and soon collapsed.

It was not until the invention of dynamo-electric machines had shown that motion, obtained without excessive waste, through the instrumentality of the steam-engine, from so cheap and abundant a fuel as coal, could be economically converted into electricity, that any financial comparison whatever between gas and the electric arc could be for a moment instituted. Even then there is an obvious disadvantage on the side of the latter, on account of the additional conversions of energy, with their attendant leakages in heat and friction, which it necessitates. Another difficulty, hardly if at all surmounted, now arises from the fact that electricity, as a source of light arising from intense and vehement action, is difficult to produce in moderate degrees, and hard to subdivide when once produced. It is not easy to realise in reading accounts of a light equal to 16,000 candles how far this is beyond the need of ordinary illumination.

The first idea as to motors which occurs to the mind is the utilisation of great stores of energy which are daily running to

waste in the form of rivers, cataracts, and tidal changes. It is remarkable that this mine of potential energy was early worked for illuminating as well as motor purposes by the mechanical instinct of a great engineer.

"A very important application of the electric current," says the "Daily Telegraph," "is now being carried out by Sir William Armstrong on his estate, about eighteen miles from Newcastle-on-Tyne. The power existing in a volume of water descending at the outfall of a Northumberland lake has been utilised by the interposition of a turbine, by means of which the requisite revolutions are given to a dynamo-electric machine. The electric current thus generated is conveyed through a stout copper wire to the private residence of Sir William at Cragside —a distance of about a mile and a half. The current is there conducted through a lamp devised on the Siemens plan, in which the regularity of the light is maintained by clockwork, subject to the control of an electro-magnet, which magnet reflects the strength or weakness of the current, so as to regulate the distance between the points of the carbon electrodes. It has been found necessary to provide a second wire to take the return current, so that the first cost of the light is somewhat large, but the working expense is very small. The light is used for illuminating the picture gallery at Cragside, and has proved eminently successful, not only in respect to the quantity of light afforded, but its purity of colour. In addition to this use of the electric current as a source of light, Sir W. Armstrong intends to avail himself of the power thus brought into his house, by applying it to several domestic purposes. This is to be accomplished by means of an electric engine situated in or near the house, and receiving the current transmitted from the machine at the lake outfall. In this way Sir William will be able to make a more constant use of what may be termed his electrical 'plant,' and thus may look forward to a satisfactory result in an economical respect. This example of the conversion and transmission of power will be viewed with great interest, the distance of a mile and a half being sufficient to indicate a much more extended sphere of action for the electric current than has hitherto been found practicable."

Immediately after hydraulic motors comes the steam-engine in one form or another. Mr. Shoolbred draws attention to the important point of regularity of motion, not only during each revolution, but also during successive revolutions. He notices the usual precautions of double cylinders, heavy fly-wheels, and sensitive governors. Where the motor power required is not great, that is, up to about 10-horse power, a gas-engine will be found convenient.

As regards the cost of the Electric Light, Mr. Shoolbred

read an instructive paper at the meeting of the Society of Arts, on December 5th. He stated that in every instance his figures and particulars were those afforded by the users of the various lights and not by the inventors or their representatives. In the case of the Holmes machine the annual cost per lighthouse was about £1,035, inclusive of interest, repairs, and wages. With the Siemens machine the annual cost was about £494 per lighthouse, including interest and the other expenses. With the Alliance machine, as used at Havre, the cost was about £474 per annum per lighthouse, interest, &c., included. The single-light Gramme machine has been in use in the Paris goods station of the Northern of France Railway for two years. Six machines have been kept going with one light each, and the cost is found to be 5*d.* per light per hour, or with interest on outlay at 10 per cent., 8*d.* per hour. The same light at the ironworks of Messrs. Powell, at Rouen, was stated to cost 4*d.* per light per hour, exclusive of interest and charge for motive power, the latter being derived from one of the engines on the works. In 1877 a series of experiments were carried out with the Lontin light at the Paris terminus of the Paris, Lyons, and Mediterranean Railway. The passenger station was lighted, and the results were so satisfactory that the company have entered into a permanent contract with the proprietors of the Lontin light for lighting their Paris goods station with 12 lights, at a cost of 5*d.* per light per hour. The Western of France Railway Company have had six Lontin lights in the goods station at the Paris terminus, St. Lazare, since May last, and 12 lights in the passenger station since June. Careful experiments have shown the cost to be 8*d.* per light per hour, inclusive of interest. Referring to the Jablochkoff light, Mr. Shoolbred placed before the meeting some particulars with regard to its application in the Avenue de l'Opéra, Paris, which were afforded him by M. J. Allard, the chief engineer of the lighting department of the City of Paris. It appears that the authorities pay the Société Générale d'Electricité 37f. 2c. per hour for the 62 lamps in use there. These 62 lamps supersede 344 gas-jets which were previously used, and which cost the authorities 7·244f. per hour. The electric illumination, however, is considered as equal to 682 gas-jets, or about double the original illumination—that is, to a cost of 14·45f. per hour as against 37·2f. for the electric light, the cost of which, therefore, is 2·6 times that of the gas. The contract for lighting by electricity was terminated by the City of Paris on the 30th of November, and the authorities have declined to renew it except at the price paid for gas—namely, 7·244f. (or nearly 6*s.*) per hour, and that only for a limited time. These terms have been accepted by the Société, so that the price paid

to them will be at the rate of about 1⅛*d.* per light per hour. Mr. Shoolbred stated that the Société place their expenses at 1·06f. (or just 10*d.*) per light per hour, which, however, they hope shortly to reduce by one-half.* A series of careful photometric experiments carried out by the municipal authorities with the Jablochkoff lights, above referred to, showed each naked light to possess a *maximum* intensity of 300 candles. With the glass globe this was reduced to 180 candles, showing a loss of 40 per cent., while during the darker periods through which the lights passed the light was as low as 90 candles. The foregoing were the only authenticated particulars which Mr. Shoolbred could obtain as regards the working of the various systems of electric lighting. In conclusion he referred to the Rapieff light at the 'Times' office, which, he observed, worked fairly and with regularity, which could not be said of all others, and it might therefore be entitled to take rank as an established application of electric illumination.

"The practical illustration," says Mr. Siemens in an excellent letter to the "Times," "of the power of the electrical conductor serves to show the possibility of application upon a large scale such as I have ventured to suggest. A true comparison between the cost of the electric current and its rival, gas, cannot be instituted until central motor stations are established in populous districts, where steam power may be produced at the cheap rate of two and a half pounds of coal per horse-power per hour, and whence radial conductors may supply the neighbour-

* Mr. Stayton's very sensible report to the Vestry of the Parish of Chelsea points out that a 16-horse power engine in Paris supplies 16 lamps, exactly one-horse power per lamp; that the candle itself costs 7½*d.*, and burns an hour and a half, being automatically replaced without visible interruption. The intensity of the light is 700 candles without, and one-third less with the globes; the ordinary London street lamp only equalling 12 to 15 candles. Each light, which only burns from dusk to midnight, costs 1fr. 45c., *i.e.* 1*s.* 2½*d.* per hour, the general cost being four times that of gas, but that a greater amount of light is obtained. Paris, it appears from the same report, is already much better lighted than London. To adopt the electric light to Sloane Street, which is 11,000 yards long and 20 wide, would require two stations with 16-horse power engines, and other machinery costing 3,200*l.* The cost of maintenance of candles, &c., would be 16 shillings per hour for an average of 3,250 hours per annum. The gas lamp now costs 8½*d.* per hour. To light the Chelsea Embankment would require an outlay of 4,800*l.*, and an hourly cost of 1*l.* 4*s.* 0*d.* The present cost is 2*s.* 1½*d.* per hour. Sloane Street, however, would be 31 times brighter than at present, which, by the way, it might well be with advantage to wayfarers. He shows that the conveyance of electricity involves enormous loss; that a little is saved by instantaneous lighting and extinguishing, that the light is safe for horses, powerful, innocuous, free from heat, but on the whole *not* suitable for street lighting, though it *is* suitable for large spaces such as Trafalgar and Parliament Squares. We entirely agree with the worthy engineer.

hood within, say, a mile radius, with both light and also with mechanical power for minor industrial purposes. The realisation of such a system involves the means of subdividing the electric current to a certain extent, a problem which offers no insuperable difficulties when continuous currents are used instead of the reversing currents which have hitherto been mostly resorted to for street lighting."

The probable uses and applications of the electric light are now becoming tolerably definite. It is clear that for extensive areas and large buildings it is of great beauty and value. To this employment of it there is, however, one drawback, namely, the intensity and apparent solidity of the shadows it throws. During the work below the level of the Thames in laying the foundations of the railway bridge at Blackfriars, it was for a time extensively used, with a view of continuing the work at night. But it was ultimately discontinued on account of the numerous accidents it entailed, from the workmen mistaking such shadows for the passage-boards leading to the bottom of the cofferdam, and endeavouring to wheel their loaded barrows upon them. If this difficulty, which arises chiefly from the great intensity and point-like character of the incandescent arc, be obviated by diffusing the light within a semi-transparent globe of opal glass, from 30 to 40 per cent. of the light is lost, and the effective cost of the light proportionally increased.

Many further improvements seem likely to be effected before long. Besides the threatened discovery of Mr. Edison, which appears to be taking a practical form, the Sun Electric Light Company, who lately addressed a communication to the Metropolitan Board of Works, have acquired certain patents, among the more remarkable of which is one for the manufacture of flexible carbon. The value of flexibility for a carbon electrode is obvious. If a strip of carbon can be wound and unwound like a piece of india-rubber, or with some fair approximation to that degree of pliancy, facilities are afforded for stowing away a long length of carbon in a small space under the electric lamp, thereby providing for a combustion which shall last a considerable time. How far this end is attained remains yet to be seen, and the Company have other patent lamps besides those in which the flexible carbon is to be employed. The Company have entered into arrangements for a trial of the electric light at the Crystal Palace. A 12-horse power steam-engine by Ruston and Proctor will be provided by the Crystal Palace Company, and a shed for its reception will be erected at the main entrance to the building, opposite the high level station. A Gramme machine to generate the current will also be placed at this spot, and the arrival of the machine from Paris is expected daily. The machine will be a small one, and is reckoned to require only $2\frac{1}{2}$-horse power to

drive it. If the experiment answers, it is anticipated that the entire Palace will be lighted up in the same manner. At first there will be only four lights, each fixed at an elevation of sixty feet above the main floor of the Palace, at the angles of the large open space under the central transept. The current will be transmitted by wires, each about one hundred yards in length, laid under the floor of the building, and converging into a special apparatus, whence other wires will proceed to the several lights, each light having its own pair of wires proceeding from the apparatus. A trial of the light, under the auspices of the same company, is also about to take place on the premises of a firm in the City. Arrangements are likewise pending for lighting up one of the large railway stations in London, and the Agricultural Hall at Canterbury.

The present excitement on the subject of the electric light occasions a great demand for the Gramme machine. Patent rights and royalties, backed up by Chancery proceedings, create some degree of obstruction in the use of dynamo-electric machines, and occasion delay in the development of processes for regulating the light. The lamp is one thing, and the machine for generating the current is another. In some cases the use of galvanic batteries is contemplated as a substitute for a machine, where only one or two lights are required. Another essential is that of the motive power by which the dynamo-electric machine is to be driven. Sir W. Armstrong's use of water-power for this purpose is very instructive and encouraging. The suitability of gas-engines to drive the dynamo-electric machine is so generally recognised, that a great demand has sprung up in consequence, and, according to some accounts, there is a difficulty in getting orders executed for the delivery of these motors, thereby giving rise to another source of delay. These obstacles in themselves stimulate invention, and it is not unlikely that some new form of dynamo-electric machine will ere long be placed before the public. The Meritens machine, lately invented in France, is stated to develope more power than the Gramme machine, in the proportion of three to one. That is to say, the Meritens machine is credited with maintaining one Jablochkoff light by the expenditure of one-third of a horse-power. On the other hand, the cost of this machine is high, being nearly double that of a Gramme comparable to it in size. The French patent for the Meritens machine is understood to have been sold for a very large sum. It may be safely asserted that there is no finality in respect to electric light inventions; and there is little doubt that many new devices, with several startling changes, will present themselves in this domain of science within a brief period of time. The Patent Office is still besieged with inventors engaged in perfecting the electric light or its accessories, and among

these people are several eminent scientists, whose efforts are not likely to be misdirected.

Among the more recent developments of electric lighting is the electric light of Mr. Van der Weyde, ordinarily utilised by him for photographic purposes, to which he was the first to apply it. It is not the production of the current nor the means of converting it into light at which Mr. Van der Weyde has laboured so much as the rendering of the light produced available as an illuminator without wasting it, so to speak, and yet without throwing the rays directly upon the object to be illuminated. His apparatus and arrangements may be described as follows :— In the basement of the house is an Otto silent gas engine of eight-horse power, which works steadily and well and without needing any attention, save at starting and stopping, goes on hour after hour driving either one or a pair of Siemens' dynamo-electric machines, as may be required, the machines producing continuous currents. The current thus produced is led up to the burners which are placed in the various studios, and which consist of two carbon rods placed vertically one over the other, the light being produced between the points. The upper rod is three-eighths of an inch in diameter, and the lower one three-quarters of an inch, and these are placed near the mouth of a concave reflector lined with white material. None of the rays of light reach the spectator direct; they are intercepted by a disc of opal glass about four inches in diameter. The whole body of the rays is gathered up in the reflector and thrown out in a flood of pure white light, in which the most delicate shades of tint are distinctly discernible. At present the consumption of the carbons is followed up by hand-adjustment, that being most convenient for photographic purposes. For general illumination, however, Mr. Van der Weyde proposes a mechanical arrangement. In fact, it does not affect his principle whatever apparatus for burning he uses; he can take the Serrin or the Siemens lamp, the Jablochkoff candle, or any other suitable arrangement. His principle consists in cutting off the direct rays from the objects to be illuminated, and surrounding them only with a white cloud of light. Mr. Van der Weyde is now engaged in a modification of his system, which will shortly be seen in an improved form in Regent Street. As regards expense, we have here some exact data afforded by the six hours during which the light was publicly exhibited on November 9. Long use of the Otto gas engine has shown Mr. Van der Weyde that the cost of the gas for it is exactly 6*d.* per hour. A pair of carbons costs 2*s.* 6*d.*, and a pair was consumed during the experiment. This gives a total of 5*s.* 6*d.*, or exactly 11*d.* per hour per light. But it is to be observed that during the experiment the second machine was at times running, so that some deduction should be made on that account. In fact, only half the power—

that of a four-horse engine—would be required for one machine, so that the cost of production would be thus reduced These calculations are, of course, irrespective of first cost of plant and machinery and of interest on capital; but they serve to show approximately the working cost of this light.

Another worker in the field of electrical science, who is at present pursuing his investigations with a view to demonstrating the indefinite division of the electric current is M. Antoine Arnaud, his patents not being yet quite completed. M. Arnaud appears to have succeeded in dividing and controlling the current, so far as experiments on a small scale are concerned. He has shown that a large number of lights can be maintained in one circuit, and that the extinction of any of the intervening lamps had no effect upon the remainder. M. Arnaud expects to be able to light a thoroughfare with a number of lamps, giving an uniform light throughout, and without fear of the extinction of one or more affecting the rest. Mr. Wilde, whose name is already honourably known in connexion with electro-dynamic machines, has introduced an ingenious simplification of the Jablochkoff candle, which dispenses with the intervening kaolin or plaster diaphragm. In a paper read before the Manchester Literary and Philosophical Society he had already pointed out the fact that when the electric light is produced from the ends of two carbon pencils placed parallel to each other the carbons will burn steadily downwards from the top until they are wholly consumed, without any insulating material between them. It was observed that even when the circuit was completed at the bottom of a pair of carbons close to the holders the arc immediately ascended to the points and remained there. This occurred in whatever position the carbons were placed. Two rods are therefore placed side by side, one being fixed, the other hinged at the base, and pressed gently against it by a spring. Directly the current passes the spring is overpowered by an electro-magnet in circuit, which separates the movable rod to the proper distance from its fellow. The need for a "priming" to start the arc is thus simply superseded.

DESCRIPTION OF PLATE II.

Chapman's Electric Lamp. Specification dated A.D. 1855, *April* 3, *No.* 739.

A. Gravity holder for upper carbon, controlled by
B. Brake-wheel and brake; the latter being actuated by
C. An electro-magnet, on closing the circuit.
D. Second electro-magnet, causing a separation between the carbons, and establishing the arc.
E E. Terminals to battery.

BRITISH MEAN TEMPERATURES.

By W. L. DALLAS, of the Meteorological Office.

IN the Himalayas, the Andes, and other great mountain chains within the tropics, a phenomenon may be witnessed which is always interesting and instructive. A traveller climbing one of these ranges advances first across valleys and small hills covered with the jungle and luxurious vegetation of the tropics. As he continues the ascent he leaves behind him the beautiful palms and immense cotton trees, the brilliantly marked birds, reptiles, and insects, the inhabitants of the tropics, and reaches the oak, the elm, and the birch, the growth of the temperate zone. These, in their turn, give way first to the larch and the fir, then to low bushes and scrub-wood, then to lichens and mosses, and finally to the region of perpetual snow. The whole of the flora and fauna have changed. Even in this short time a journey has in reality been effected from the equator to the pole; yet the lie of the land is the same, and the air is the same, the whole atmospherical conditions are only slightly modified, with one great exception—and that exception is, temperature.

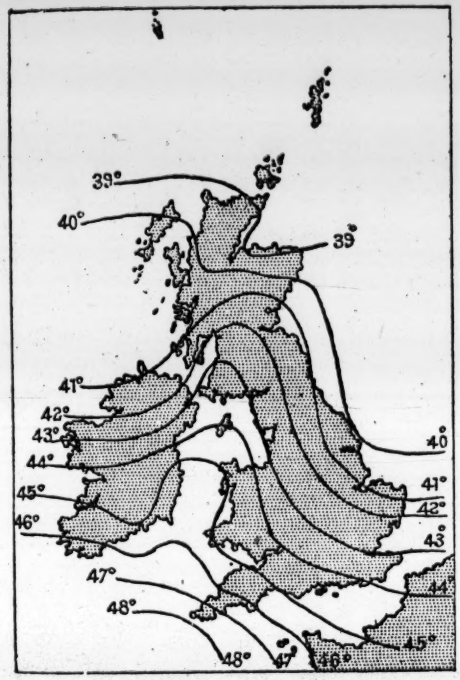
Difference of temperature is thus shown to be sufficient to gather the products of all the different zones of the earth into one small region, demonstrating practically and plainly the importance of temperature to every inhabitant of this world. Any contributions, then, which are made to our knowledge of this the most important factor in climate, must deserve and receive interest and attention from every one. More particularly is this the case when the contribution is made by the Meteorological Office, as in the case of the recently-published Tables; for, coming from such a quarter, it carries a guarantee that the observations have been taken with that regard to uniformity both of instruments and exposure which is so necessary for a proper comparison of the temperatures of different places. Instructions for taking temperature observations have been prepared; and in many cases every effort has been made to secure uniformity in the hours of observation, the nature of the screen, and in the instruments from which the observations are to be

taken. But, whatever the method of observation may be now, it can scarcely be disputed that in former times there was a margin for improvement; so considerable, in fact, that it is difficult to understand how to accept the present arrangements as approximately correct, and yet regard the previous observations as having any claim to scientific accuracy. Everyone can understand how, when it was left to the discretion and taste of amateur meteorologists to employ screens of any shape and position they pleased, the vagaries and opinions of the different workers should have led to an endless variety of form and exposure. It can, therefore, occasion no surprise to read in one of the publications emanating from the Meteorological Office that at the time of the first inspection of stations it was found that thermometers were placed in some cases under station roofs; that at one place the wet bulb had never seen water for about three weeks, while in another it had been completely immersed in that element for about the same period. All these sources of difference having been eliminated, and uniformity of exposure and time having been obtained, it must be evident that these observations may be regarded not only as the latest but most correct data to be obtained of the temperature of the different parts of these Islands.

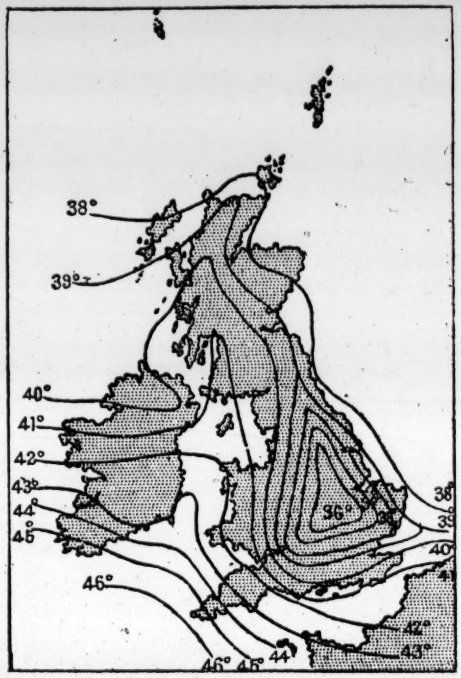
The best and plainest method of displaying quickly and clearly the general distribution of mean temperature over our Islands is to plot the observations on charts, and the following figures give the isotherms for each of the twelve months.

January.—The influence of the waters of the ocean, and more particularly those of the Atlantic, in modifying climate, has been repeatedly pointed out, and this influence is clearly shown in the January chart. The warmest station in the British Isles in this month is Scilly (48°); for not only is it the most southern point of our coasts, but it is surrounded on all sides by the heat-bearing waters. Next in order after the Scilly Islands come Valentia, on the south-western promontory of Ireland, and Plymouth (both 46°), both stations well exposed to the warm south-west winds and the open sea. From this warm south-western region temperature gradually decreases in a north-easterly direction, and reaches its lowest point (39°) on the coasts of the Moray Firth. Although this is actually the coldest part of the kingdom, it will be noticed that the temperature of the whole of the east coast of England is very little more genial; the isotherms, after having been carried well to the northward on our western coasts by the influence of the warm Atlantic, turn almost at right angles in a southerly direction till they come to a region which is again, though in a more modified degree, heated by the waters of the ocean, viz. the shores of the English Channel, when they again take a more easterly course.

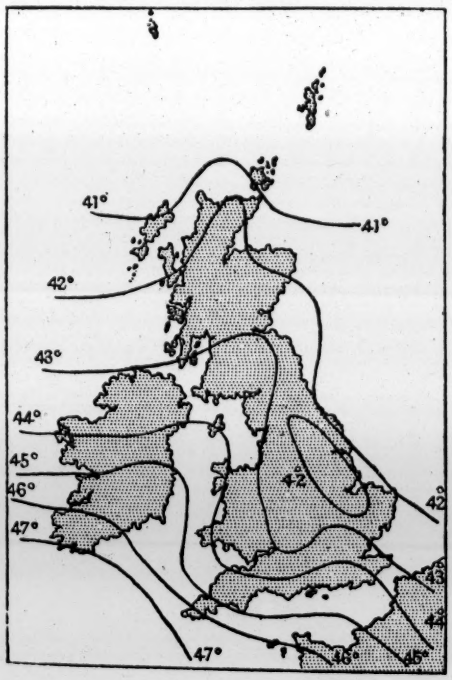
1. JANUARY.



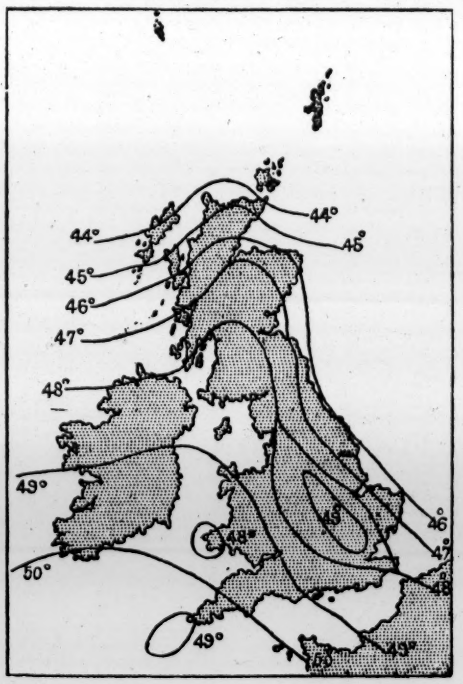
2. FEBRUARY.



. MARCH.



4. APRIL.



February.—The main characteristics of the January isotherms are again seen in the February chart; the temperature readings are shown gradually decreasing from the Scilly Islands (46°) to the north-east of Scotland (38°), while the same sharp angle southward is observable in many of the isotherms. But it will be noticed that, so far from the coldest region being now the coasts of the Moray Firth, a narrow band of still lower temperature is shown stretching across south-eastern and central England.

March.—This chart shows a general increase of warmth; and this being greater over central England than elsewhere, readings are more uniform, and the isotherms more regular. A small area of low temperature is, however, still shown over the northern and central parts of England, York having the same mean temperature as Stornoway and Wick, while the isotherm of 42° runs southward from Thurso through Aberdeen, Shields, &c., as far as Cambridge and Yarmouth.

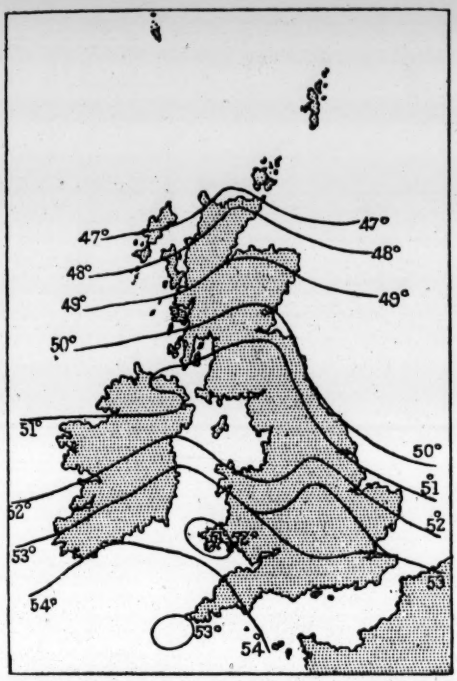
April.—The influence of the sea is beginning to be shown operating in the opposite way to that which we have observed in previous months, while the sun begins to exercise considerable influence on the land. Scilly is not so hot as the mainland stations of Cork and Plymouth, while the comparative coldness of the northern islands is shown by the crowding together of the isotherms over the northern part of the mainland of Scotland. At the same time over that part of central England where formerly we found a cold region, the sun now possesses sufficient power to raise the day temperature to a height which produces a mean temperature superior to that of the surrounding districts. The more eastern parts of England are still cold, the isotherms having still a north and south direction on our east coast.

May.—A further general rise of temperature occurs during this month, amounting, as a rule, to about 3°. Cork and Plymouth again show the maximum mean temperature, but the isotherms are not so crowded together in the north of Scotland.

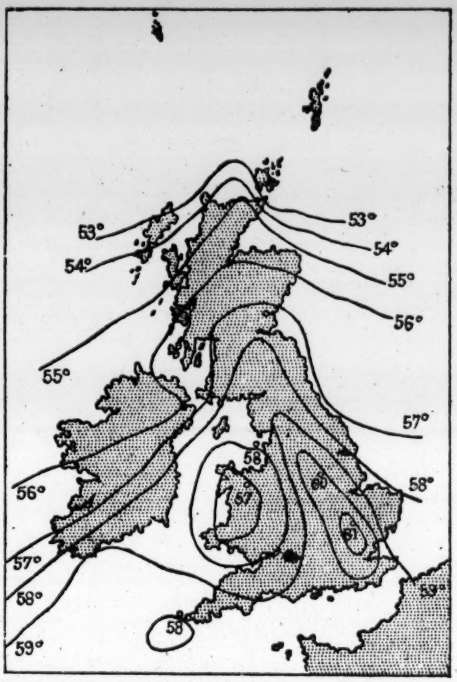
June.—A rise is shown over the whole country, the mean temperature now varying from 61° in the south to 53° in the north. Over the greater part of the country the increase is about 5°, but over central and southern England it amounts to as much as 8°. The hottest district is that around London, whence a narrow band of high readings extends northward over central England. It will be observed that all the isotherms send a narrow promontory northward over the central stations, showing the influence of the sun in raising the heat of the inland stations, and that of the sea in tempering the heat of the coast.

July.—A further rise of 3° or 4° is shown; but otherwise no great change has occurred, the relative distribution of the isotherms being very similar to that of June. July is the hottest month in the year.

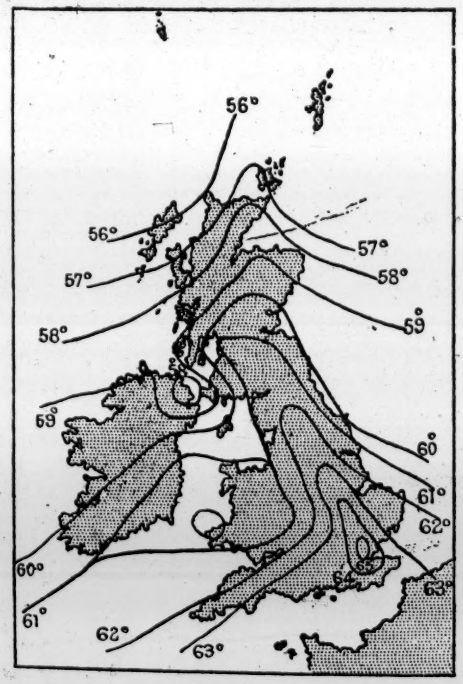
5. MAY.



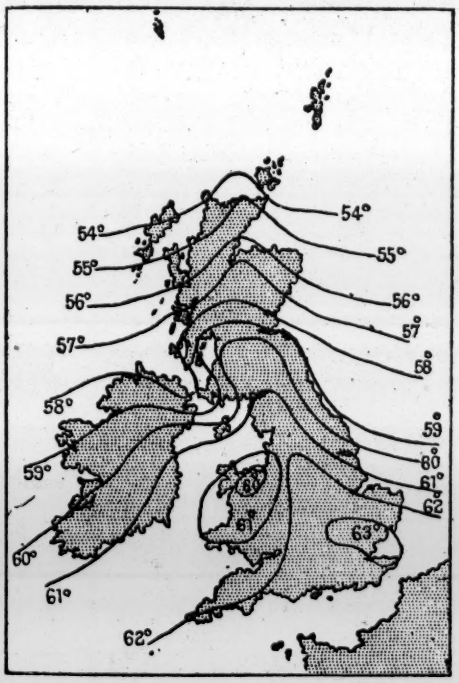
6. JUNE.



7. JULY.



8. AUGUST.



August.—Temperature now begins to decrease again. A fall of one or two degrees is noticed both in the Thames valley and in Scotland, but the changes elsewhere are unimportant. The northern islands of Scotland appear to be getting colder, as the isotherms are again crowding together over North Britain.

September.—A fall of 3° or 4° has taken place over the whole country. The isotherms are more uniform and regular in this month than any other, though there is still a slight ridge to the northward over the central stations.

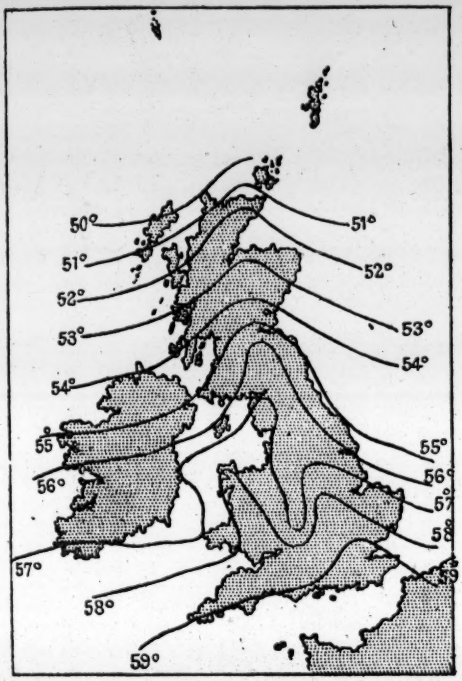
October.—A rapid fall has occurred amounting to 5° or 6° in the north and to 8° or 9° in the south. The warmest place is once more the Scilly Islands; while, owing to the excess of decrease in the south as compared with the north, the isotherms are becoming wider apart, and the chart is acquiring more the appearance observed in the spring.

November.—The thermometer shows a further decrease, though the difference between November and October is not so great as that between the last-named month and its predecessor. The warmest point is still Scilly. The isotherms turn sharply southward over England, and a small region of low temperature is appearing over the central parts of the country.

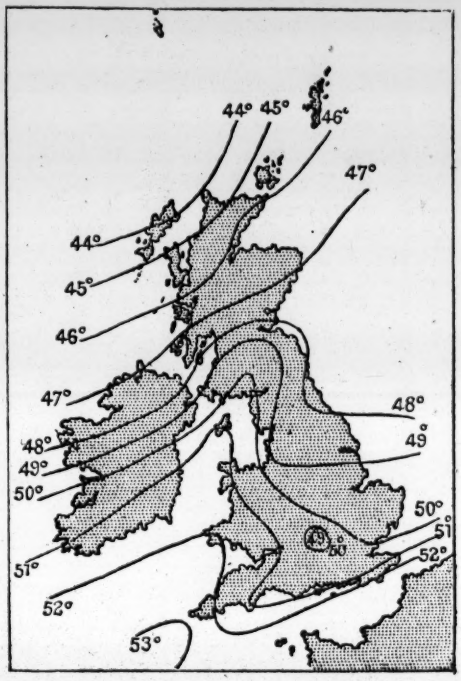
December.—A further decrease has occurred everywhere; but the change is again greater over the central stations than in the west and north, so that the cold region has become much more pronounced. This chart affords an excellent example of the rapidity with which temperature decreases as we travel inland from the western coasts, the isotherms between Holyhead and Nottingham being exceedingly close together. The temperature of this month bears a very close resemblance to that of February, though at some stations February is the colder of the two.

As we have advanced through these charts, numerous instances of the influence of the sea have been mentioned; but its power is much more noticeable when discussing the maximum and minimum observations than when dealing with the means of such readings, the great difference between what are termed continental and insular climates lying in the large range of temperature in the one case as compared with that in the other. Taking, then, a mean of the maxima and a mean of the minima, we much more readily realise the sort of climate which prevails at a given station than if we confine our observations merely to the mean temperature. Within our islands it is of course impossible to show any very extensive range in the thermometer, the climate, though varying somewhat in degree, being thoroughly insular over the whole country. Thus no station within our limits has a climate anything like that of Quebec, which, lying in the same parallel as central France, enjoys summers

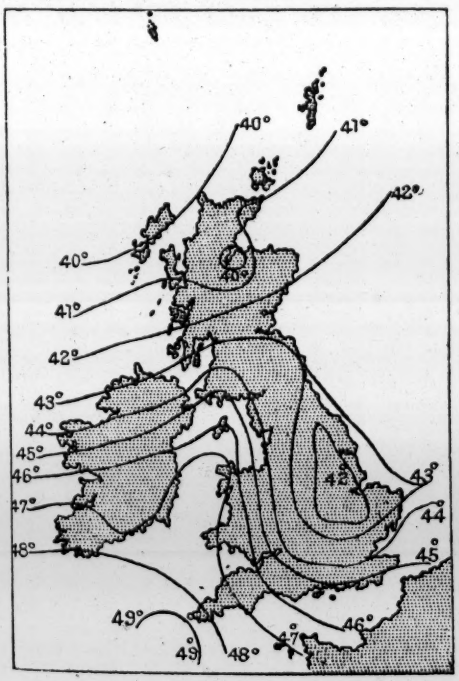
9. SEPTEMBER.



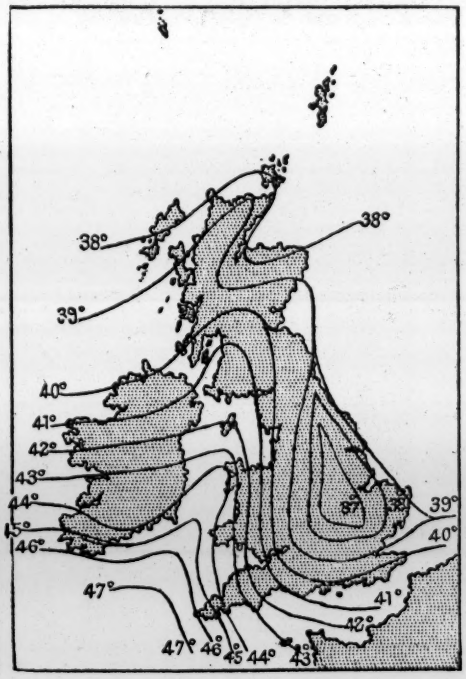
10. OCTOBER.



11. NOVEMBER.



12. DECEMBER.



as warm as those at Paris, and experiences winters as cold as those at St. Petersburg. Nevertheless a comparison of the maximum and minimum readings will show that within the narrow compass of the British Isles the phenomena of continental and insular climates are, though on a very small scale, as distinctly to be traced as on the great continents of Asia and North America.

If we take the mean maximum of the hottest month of the year, and the mean minimum of the coldest month of the year, the difference will show the average annual range of temperature at the different stations. Arranging them in threes from west to east, as nearly as possible in the same parallel, we find :—

	July Mean Max.	February Mean Min.	Range
Stornoway	62°	33° =	29°
Nairn	66°	34° =	32°
Aberdeen	65°	34° =	31°
Moville	64°	37° =	27°
York	71°	31° =	40°
Shields	66°	35° =	31°
Valentia	65°	40° =	25°
Nottingham	74°	31° =	43°
Yarmouth	68°	34° =	34°

From these figures it will be seen that on both sea-coasts the climate is eminently insular ; while over the central parts of the country it is in a slight degree continental. The difference would be still more marked were the waters of the North Sea as equable in their temperature as those of the Atlantic.

The remaining portion of the tables just published deals with observations which, though interesting, are of less importance than the observations we have just been discussing. They are the extreme temperatures which have been experienced over the country during the whole period over which the observations extend. They are interesting as showing to what degree of heat or cold we are liable ; and in some cases no doubt this might be important ; but it is impossible to give any summary of the results. The readings show, however, to what a very large range of temperature the central parts of the country are subject, notwithstanding the favourable position of these Islands, the thermometer carefully shaded and exposed having, during the three or four years under discussion, risen at one time to 91°, while at another it has fallen to 10°, showing a range of 81° in the short interval of five years.

The mean temperature given above must be regarded by the agriculturist and the farmer in a very general and liberal spirit,

as giving only the main characteristics of the mean monthly temperature over our Islands. So soon as details are entered into it will be found that in contiguous districts considerable variations are occasioned by purely local influences, such as the lie of the land, the drainage, the amount of wood in the neighbourhood, and the quality of the soil. For instance, in the Thames valley the general surface clay is pierced in several places by the sandy, gravelly stratum which underlies it; and observations of the temperature of the air, made simultaneously over the different soils, would probably give very different results. After a shower of rain the water would soon disappear from the loose sandy soil, and the sun's rays would immediately heat the earth and the superincumbent layer of air; while on the clay the water would remain and keep the temperature down. Thus, while the isotherms on the different charts give the main distribution of temperature, due allowance must be made for such local influences as have been described above. The different cereals with which a farmer is principally concerned, though showing considerable climatic adaptability, are yet very sensibly affected by the temperature, and their profitable cultivation can only be carried on within strictly defined limits. Thus, wheat cannot be grown with profit in the north of England at a greater elevation than 700 feet above the mean sea level; and in the Orkneys, though it has been repeatedly tried, and generally produces an abundance of straw, the grain is seldom of any service. Oats, rye, and barley show a much wider geographical range than wheat; but neither oats nor rye can be grown profitably in the Farö Islands, and though barley is still cultivated there the success is very limited. This is due to the strictly insular character of the climate of these Islands; for in Norway, in lat. 71°, or about 10° lat. further to the northward, both barley and rye grow freely, adapting themselves to the short, hot summer which prevails on the Continent in those latitudes. In fact, such is the speed with which vegetation progresses in situations from which during the summer the heat and light of the sun are scarcely ever withdrawn, that sixty days is the ordinary interval between sowing and reaping.*

To the doctor a knowledge of the climate of the different parts of our Islands is of immense importance as determining the health resorts most suitable to the various patients under his care. It appears from statistics that the moist, equable climate which characterises the west coasts of Ireland and Scotland is much more healthy than that of England, and still more so than that of the continent of Europe; so that the percentage

* Morton's "Cyclopædia of Agriculture."

of deaths increases as the coast is left behind. A continuously cold or a continuously hot climate it is possible to endure; but great extremes, following each other in quick succession, immediately cause an increase of the death rate in the Registrar-General's return. The very cold winter which occurred in 1860 occasioned as many deaths as a severe visitation of cholera; and the death rate for the different diseases increases or decreases in a perfectly regular manner according as the climatic conditions are favourable or unfavourable to each particular disorder. Dr. Williams, in his little work on the "Influence of Climate on Consumption," mentions that the natives of Tahiti are liable to an exceptionally malignant form of that disorder, and shows that it is due purely to climatic influences peculiar to those islands, and not to the physical organisation of the natives. To prove this he quotes the fact that during the time the French frigate "Serène" was in port there, many of the sailors were attacked by a similarly severe form of consumption; that twelve died, and many others had their lungs affected. On the other hand, the same writer mentions that a Swiss who was domiciled at Panama, and who was attacked by a very severe form of consumption, regained, on ascending the mountains as high at Quito, all his former health and strength, only, however, to lose them again on his return to his old quarters. These two experiences prove the influence which climate exercises on the progress of disease, and the great importance of medical climatology. It will be plainly seen that, in the case of the British Isles, to patients living in the north and who during the winter require a warmer climate, the mere journey southward would be of no avail, without a corresponding movement in a westerly direction, because during the winter months the temperature of eastern and central England is at least as low as that of the east of Scotland, and during some time of the year is even lower; while, to improve upon the climate of the west of Scotland, it would be necessary to go to the extreme south-western coasts of England. In addition to this it is proved, by an investigation of the Registrar-General's returns, that no sooner does temperature fall to a certain *low* point than the death rate among patients afflicted with certain complaints immediately increases, while so soon as it reaches a certain *height* the mortality from certain other diseases increases. It consequently follows that the inhabitants of central England, where the weather is colder in winter and hotter in summer than elsewhere, are liable to more diseases than the inhabitants of the western part of the country, always supposing, of course, the other conditions to be equal. Messrs. Buchan and Mitchell of Edinburgh, in a singularly exhaustive and interesting paper, have traced the con-

nection which exists between disease and temperature, and have shown by means of curves, drawn according to the percentages of deaths above or below the mean number for the year, the oscillations which occur as the weather changes. Some of these curves, which have been drawn for all the disorders for which the Registrar-General's returns furnish data, are exceedingly well marked.

The curve for diseases of the respiratory organs shows a maximum during the first two weeks of January, and a minimum in the last two weeks of August; while the curves for dysentery, diarrhœa, and cholera show that during the greater part of the year deaths from these causes are very much below the average for the year; but that during July, August, and September the percentage of deaths above the mean increases with frightful rapidity. These are the most strongly marked of the curves; but, in nearly all, some relationship may be traced between the climate and the number of deaths. Even suicides, murders, and homicides, as well as such diseases as delirium tremens, show that they are amenable to certain climatic influences, and exhibit regular periods of maximum and minimum intensity. Of delirium tremens, Messrs. Buchan and Mitchell say: "Deaths from this cause have a well marked annual curve—it rises above its average in the middle of May, attains its absolute maximum in the latter part of July, thereafter falls to the average in the last week in September. Its absolute minimum is during the first half of December; and it continues below the average from October to the middle of May, with the singular exception of the Christmas and New Year period, when there occurs a short continued secondary maximum." This secondary maximum is probably due to disturbing influences other than the weather.

Such are the main characteristics of the temperature of the British Isles for each month of the year; and it only remains to say that the means from which this paper is compiled are those just published in the "Quarterly Weather Report," pt. 3, 1875; that they are derived from the maximum and minimum observations made at different stations over the country; and that they extend, *as a rule*, over a period of four years. Such a period is, it is well known, generally considered to be too short for the deduction of perfectly reliable temperature means; but whatever deficiency the present observations have in regard to length of time, is probably largely compensated for by taking into consideration the fact that they refer to a period which has only just passed, the superiority of the instruments used, and their better exposure and uniformity. Besides, in addition, it has been proved by incontestable evidence that every marsh that is

drained, every wood that is cut down, and every bog that is reclaimed exercises a great influence on the climate of the country in the immediate neighbourhood; so that, having regard to the great improvements of the soil which are in progress on all sides, it must be evident that, even in the short period that has elapsed since the last of these observations was taken, modifications may have arisen which, before many years are over, may cause the present means to be very far from representing the actual temperature of our Islands.

THE ORIGIN OF TARNS.

By the Rev. J. CLIFTON WARD, F.G.S., F.R.M.S.

WHO has not felt a sudden and intense pleasure when, rounding the end of some mighty mountain or towering crag, the still waters of an upland lake or tarn have first met the eye? Perhaps, on approach, wild birds have started from the smooth surface and left it a little sea of shimmering gold, as the sun's light has been reflected from each tiny wavelet. The raven's croak among the overhanging cliffs, the patch of snow lying unmelted deep in a rocky fissure, the scattered sheep browsing carelessly on the few grassy slopes, while all around are masses of tumbled rock, and the light veil of cloud that ever and anon sweeps the cliff tops and adds an air of mystery and wonder to the whole—all combine to make a scene which cannot but send a thrill of pleasure and perhaps of happy awe to every heart. Instinctively one feels, if the power of expression be not present, what nature's true poet hath so truly sung.

> How divine
> The liberty, for frail, for mortal man,
> To roam at large among unpeopled glens
> And mountainous retirements, only trod
> By devious footsteps; regions consecrate
> To oldest time! and, reckless of the storm
> That keeps the raven quiet in her nest,
> Be as a presence or a motion—one
> Among the many there.

No one can wander over rugged and beautiful mountains without being led to love and admire these calm sheets of water, which lie nestled in hollows, and are ofttimes blackened by the shadow of encircling cliffs. Love for such solitary spots soon excites our curiosity as to the origin of these miniature upland lakes. In the Cumbrian lake district they are scattered broadcast over the country in far greater numbers than most people imagine, and at a period not vastly remote their number must have been more than double what it is now. But the

yearly waste of mountain side and the matter brought down by every stream have filled up many a mountain pool, and frequent peat mosses mark the spot where once the waters danced in the mountain breeze. Whence these hollows? What is their origin? Do we see in them the relics of volcanic effort? Are the combs (cwm), coves, or corries in which they lie the vestiges of volcanic craters, as the form of many at first, perhaps, suggests? Or have we here hollows produced directly by surface action? Again, are these hollows of great depth, or are they shallow? What is their general form? Now, there is little doubt that most people, if asked to draw the form of the hollow in which the waters of a tarn now lie so placidly, would grossly exaggerate its true depth, or, perhaps, liken it to the basin formed by placing the two hands together, side by side, curved, with the palms uppermost. Some years since I took a number of soundings among the Cumbrian lakes and tarns, and communicated the results of my examination to the Geological Society (Quart. Journ. Geol. Soc. vol. xxx. p. 96, and vol. xxxi. p. 152). Hold out one hand, palm uppermost, and straighten it as much as possible—the hollow in the palm is yet far too deep to represent with truth the natural rock basin. Soundings taken in lakes throughout the district all show the same thing—the basins are very shallow compared with their size and the height of the surrounding hills.

Next, let us search out the origin of these shallow basins. At the outset we distinguish two classes of action, one of which must have been at work. Either the matter formerly filling the hollow has been dug out and carried away by some agent working at the surface; *or* force from below has here sought a vent, and dispersed the matter far and wide; or, from failing support, the ground has sunk at this spot into a hollow.

First we will consider the upward or downward theory. If these numerous mountain hollows with included tarns be of volcanic origin, then it is clear we shall find the *signs* of a crateral hollow such as we see them in many parts of the world at the present day. There are no such signs. It is true that in many cases the surrounding rocks are of volcanic origin; but the volcanic beds, in their lie and position, show no manner of relation to the tarn hollows; and a little study of the rocks of the district and the form of the ground clearly shows that the volcanoes which gave rise to the ashes and lavas forming many of Cumbria's highest mountains, were active, not as but yesterday, but in untold ages past. Then, as to the *downward* or *special depression* theory, when we can conceive such minute subsidences taking place at a great number of almost microscopic spots without affecting the rocks around, or leaving any evidence of a sinking away, we may admit it as possible.

If not produced by expulsion of matter outwards or sinking of matter inwards, these hollows must be the effect of some surface-working agent. The sea *planes* away along the coast-line, and the material goes to *fill up* ocean hollows; therefore the sea cannot be the agent, and any force in an ocean *current* is clearly out of the question over these scattered *spots*. Streams and rivers work along lines, form ravines and gorges, but never a more or less circular basin of great size in comparison with the stream, or river; hence they cannot be the agents. The atmospheric powers—rain, snow, wind, and chemical action—weather the rocks indeed, form tiny basins on almost every stone; but this is but nature's fretwork, the delicate carving around the sculptured craggy tower or spire and smooth-scooped rocky front. Yet there is one surface agent remaining, the moving glacier. Most people are familiar with the proofs of former glacial action in Cumberland and Wales—proofs as clear as are those of the former greater extension of the Swiss glaciers. Now by far the greater number of our tarns lie in true rock basins—hollows completely enclosed by rocky sides, which are, moreover, smoothed and grooved in a manner peculiar to ice action. At the sides of many a tarn and lake you may see the ice grooves and scratches passing beneath the water, so as to leave no doubt whatever that ice has once occupied the rocky hollow. The question is, Did the ice movement form the hollow? I believe that in most cases it did, and for these reasons: 1. The tarns lie almost invariably in the path of old ice streams or glaciers, as is proved by the direction of the scratches in the surrounding rocks. 2. They *frequently* occur at the foot of slopes more or less steep, or where the ice pressure can be shown to have been great. 3. The position of the deepest points in the larger tarns and lakes occurs almost invariably where, from the confluence of two or more glaciers or the narrowing of the valley, the ice pressure must have been somewhat increased. 4. The depth of these tarns is very slight as compared with the thickness of the ice which can be proved to have passed over them. 5. There is every gradation from a tiny rock-bound pool, glaciated on all sides, and which all will admit must have been scooped out by the ice, to the tarn or lake showing precisely similar phenomena on a larger scale.

Since the ice plough passed over our land the atmospheric powers have been at work for a long period, and while many rock basins are now completely filled up by stream-borne matter, all are *being* so filled, and each age must witness a decrease in the number and size of those sheets of water which form so marked a character of our Cumbrian scenery.

Before quitting this subject, however, I must remark that there are a few tarns which seem to me to owe the whole or a part of

their depth to a moraine dam. That is to say, the rock basin is imperfect on one side, and there an old glacial moraine may have helped to dam the waters back ever since the retreat of the glacier which threw off the moraine. It frequently happens that a little moraine material has been left upon ice-rounded rocks at the foot of a tarn, and in such cases a hasty observation might lead one to believe that the whole mound was a moraine. Let us remember, then, that a tarn may lie in a complete rock basin, ice-formed; in a glaciated hollow dammed on the lower side by a moraine or other accumulation of rocky débris; or it may owe part of its depth to a rock-enclosed hollow, and part to a morainic dam. Therefore, on a summer's day, as we lie dreamily gazing upon the rippling waters of these mountain tarns, we may sometimes think of an age which is past, when the ice-sheet moved majestically over the now heather-clad fells, and all the country lay "clad in white samite, mystic, wonderful."

ON THE EXTENT OF THE GAP BETWEEN CHALK AND EOCENE IN ENGLAND, AND ON SO-CALLED UPPER CRETACEOUS FLORAS.

By JOHN STARKIE GARDNER, F.G.S.

MOST of those possessing even but a superficial acquaintance with geology in England are aware that the Eocene strata in this country invariably rest, often conformably, upon the Chalk. Those who have collected fossils from the rocks above and below the Chalk are familiar with the complete change in the fauna belonging to each. The thoroughness of the change is recognised in the fact that from the Chalk downwards the rocks are considered to be *Secondary*; while strata above the surface of the Chalk are recognised as *Tertiary*. Although frequently but a slightly eroded surface and a few water-worn flints actually separate them, a vast interval indeed separates them in geological time. So immense must the time have been, that strata 10,000 feet thick may have been accumulated in other parts of the world during its lapse. Few geologists, however, appear to have realised this possibility, and we therefore find, when beds unmistakably of this middle age are under examination, that the question as to whether they are of Cretaceous or Eocene age is hotly disputed. We also usually find that when there is any internal evidence of a bed, especially if containing plant remains, being older than the known Eocenes, it is at once stated to be contemporary with one or other of our Cretaceous formations, even when a comparison of the fossils, especially of the plants, would point to the impossibility of such being the case. I will endeavour to make the magnitude of this gap apparent.

The Eocenes are composed, without exception, of the comparatively local deposits of shallow seas, estuaries, and rivers, even those most essentially marine in character containing evidence that land was not far distant. The Chalk which stratigraphically precedes them, contrasts with them very strongly, being

purely oceanic, deposited over a wide area, and containing no indication whatever of the proximity of land. Confining our remarks for the present to England, we see that the Eocenes, some 2,000 feet in thickness, are the results of a chain of perfectly natural and connected events which can be traced. They are essentially detrital deposits, while the Chalk is oceanic. But although we can trace the deposition of the Eocene through every stage, as if it were a written book, when we attempt to connect its history with the deposition of the Chalk, we find the records are missing. How the Chalk area became converted from ocean to land, and for how long a time it had been land before the deposition of the Eocenes commenced, are questions which can only be solved, if solved at all, by a study of the rocks of other countries. In France, an older group of Eocenes exists than we have here; but even this is, apparently, quite as remotely separated from the Chalk as our Eocenes. The break is so absolute and complete, indeed, that the Cretaceous period again seems to us as distinctly separate from the Eocene as it was thought to be by the earlier geologists.

We have every reason to believe that the Chalk, being an ocean deposit, must have formerly covered wide areas, and that the existing masses, although still extensive, are but mere fragments which have escaped denudation. It is not surprising to find, therefore, that besides those portions of Great Britain and Ireland which, from its actual presence, were obviously covered by a continuous Chalk formation, its former extension over the whole of Wales, Scotland, great part of Ireland, and the Scilly Isles, has been traced. We may thus safely infer that it stretched, at least, continuously over Great Britain and far over Europe and the adjacent seas. But we scarcely know at all what were the limits on the present land surface even of the ocean which deposited it; for although there are Cretaceous deposits in Europe thought to indicate proximity to a shore-line, it is not ascertained whether these are truly contemporaneous with the Chalk of England, or whether they are the deposits of that later period when the ocean began to recede, prior to the elevation of part of its bed into præ-Eocene land.

The denudation of the Chalk, which must have been on a most colossal scale, had doubtless proceeded for ages before the deposition of the Eocenes commenced, since even their lowest beds consist of extensive tracts of flint ground into sand and pebbles. It has continued ever since, to how great an extent we learn but imperfectly, by the enormous beds of gravel and sand which form, to a large extent, the Eocenes, Pliocenes, and Pleistocenes, and by the shingle and sand banks of our present littoral.

But, in addition to this evidence, we have other and stronger

reasons to infer that the lapse of time was of vast duration, from the striking and complete changes which took place in the fauna and flora in the interval. From the commencement to the close of the Eocene period, as it is represented in England, the aggregate amount of progressive change is, notwithstanding repeatedly varied physical conditions, by contrast trifling, and it seems to have been effected so gradually that the types of life in the oldest and the newest Eocene are substantially the same.

The change in the types of the fauna throughout the Cretaceous period is also so small as to be almost entirely of the value now commonly recognised as specific and not generic. From the Neocomian to the Grey Chalk, wherever like conditions prevailed, the same groups of genera, especially if we take the Mollusca, are seen to reappear. The fauna and flora of each of these periods are, although much interrupted, continuous and similar, and notwithstanding that unrepresented intervals are indicated, there is no great break in geological time.

The Cretaceous and the Eocene faunas, on the contrary, seem, when compared together, to have nothing in common, and so complete a change had taken place in them, that even the gap between the Jurassic and Cretaceous periods, judged by their organic remains, was small compared to this. How or when the Cretaceous fauna disappeared, we cannot trace in this area; we only know that it existed in seas which deposited the Chalk, and had ceased to exist here when the Eocene time arrived. Yet we know that the extinction must have been a natural and gradual one, since we see in America, and also in many other countries, that chambered Cephalopoda and *Inocerami*, for example, of late Cretaceous types lived long after the time in which we have any record of them in this country, mingled with mollusca, whose general features are strikingly similar to those of our Eocene.

The inference from all this is necessarily, that great as the lapse of time must have been during the accumulation of Cretaceous or Eocene, immeasurably greater was the period, of which we have no record here, which elapsed between the close of the one series and the commencement of the other. We might reasonably, therefore, expect to find in other parts of the world, deposits thousands of feet in thickness, belonging to the intermediate or Cretaceo-tertiary age, as Hector has named it, without, perhaps, even then having the gap entirely filled up. We believe that ocean spread widely over Western Europe, at least, in the Chalk portion of Cretaceous times; and it would therefore be almost impossible that any but the merest traces of the land vegetation of that period could be met with in our own or even in any adjacent country.

We know, it is true, but little of the earlier Cretaceous floras, but what we do know of that of the Neocomian shows it to be closely similar to the Wealden flora, and this has most affinity with the Jurassic. In the Gault I have collected, with the assistance of John Griffiths, at Folkestone, for 20 years, and five new species of cones have been described by Mr. Carruthers from the collection I have made alone. Notwithstanding that branches of conifers with leaves attached are by no means rare, that a variety of cones have been found, and that wood and resin is abundant, no trace whatever of a dicotyledon has been met with. In a Gault deposit of Hainault eight distinct cones and much wood, both of conifers and cycads, were met with, similarly without the presence of any dicotyledon.* Neither has any trace of them been found in the Green-sands or the Chalk. Notwithstanding this, it has been said that the Gault contains the dawn of the present flora; but we see at Folkestone that the Gault fauna melts most gradually into that of the Grey Chalk overlying it; and therefore if any inference may be drawn, it would be, that as we see even a less amount of change in the flora than in the fauna from Jurassic to Cretaceous, and in other times, whenever it has been possible to observe it, there is no reason to suppose it changed more rapidly than the fauna between Gault and Chalk. Without, I hope, attaching undue importance to negative evidence, it must be allowed some weight in the absence of any other kind, and in this instance, it is against any flora which contains dicotyledons being as old as our Chalk, and far more, the Gault.

Certain floras, described as Cretaceous, have been met with in Austria, Saxony, Bohemia, Silesia, Moravia, some of which have been stated to be of Lower Chalk-age; and a considerable flora, reputed to be contemporary with our Upper Chalk, has been collected at Aix-la-Chapelle. The age of these deposits however is of the greatest uncertainty, and has been recognised upon mere opinions, which have differed so much at times that the same beds have been assigned to very different divisions of the Cretaceous, and even to other and younger series. The lithological characters and the nature of the floras render it probable that the Aix-la-Chapelle flora especially may be Eocene, and the others rather older, but of a period long subsequent to the Cretaceous formation in England. The diversified characters and frequently Eocene aspect of these supposed newer Cretaceous floras, wherever they are found in Europe are so opposed to the intimate interconnection existing between those of the Eocene and Miocene of the same area, as to furnish additional proof that their ages must be very various, and

* M. Coéman's "Flore fossile de Hainaut."

cannot in all cases have been rightly determined. The very reasons which render it unlikely that any floras of Chalk age or remotely separated from the Eocene, should exist in our area, make it the more probable that they are to be met with in distant localities. The Chalk ocean did not extend over all the globe, and some floras should be found, as it is unlikely that all vestiges of land deposits of a period presumably of far longer duration than the whole Eocene time should have been swept from every part of it. And we find this to be the fact, for within the Arctic Circle have been found the remains of an evidently Cretaceous, and another which I take to be a præ-Eocene flora. In New Zealand we find a Cretaceo-Eocene series of great thickness, near the base of which occurs "an abundance of fossil leaves of dicotyledonous trees, zamias and palms."* In Vancouver's Land there are 4,000 feet of strata overlying the Nandimo coal beds, containing ammonites, baculites, and *Inocerami* from top to bottom; yet these are mingled with Eocene and even Miocene forms of mollusca, and are associated with oak and poplar leaves.† In India, an otherwise Cretaceous fauna includes gasteropoda with a decidedly Tertiary facies, and this appears to be the case in still other countries.

In America, great consecutive series of deposits, resting on old rocks, and extending in time from some post-Cretaceous date to the Pliocene, contain extensive fossil floras. A great part of these have been described by American writers as Cretaceous, from the intercalation of marine beds with some animal remains, characteristic in Europe of the Cretaceous period. But it seems certain, from the mixture of characteristic Eocene types, that the existence of these forms was continued for a prolonged period in America after it had ceased here. We also see that a land fauna including Cretaceous types, and a peculiar, simple, and probably indigenous flora, since it has not been met with elsewhere, lived there for a long time, isolated from the more advanced types which flourished in Europe. These appear to have been almost suddenly replaced by a fauna and flora of newer and more tropical character, and, in many respects, allied to our Eocene, when land communication existed between the two hemispheres in Eocene times. The whole evidence, when carefully weighed, tends to prove that all the plant-bearing beds of America, containing dicotyledons, which have been described as Cretaceous, are of Cretaceo-Eocene age. They thus become of great interest, as partially, at least, filling up the great gap existing in Europe.

* Hector, "New Zealand Institute Trans." Vol. iv., 1871, p. 345.

† Geol. Surv. Canada, 1873-74, p. 260.

It appears, therefore, although only upon strong negative evidence, no other being possible, that dicotyledons did not exist in floras so remote in age as the Gault. There is even no direct evidence that they existed during the Chalk, for no dicotyledons are yet known from it or beds *ascertained* to be contemporary with it. The date of their first appearance is still uncertain; but in Greenland, a leaf of simple form, ascribed to a poplar, is seen with what appears to be evidently a true Cretaceous flora. Of the many other so-called Cretaceous dicotyledonous floras, whilst some, as that of Aix-la-Chapelle, are, if botanical evidence can yet be said to be of any value, probably Eocene; others appear, at most, to be præ-Eocene. Between the Eocene and Chalk there is an immense gap, represented elsewhere by important formations, and to this period the older dicotyledonous floras may, for the present, be safely referred. The true Cretaceous floras are still almost completely disconnected from those which are post-Cretaceous; but we know so little of the relative ages of the latter, that it is safer, at present, in speculations, to leave out of consideration all groups of plants which are from beds whose age is not stratigraphically determined. It is most important that the existence of this intermediate zone should be clearly recognised, and the name made use of by Hector, "*Cretaceo-Eocene*," might well be adopted. The term "Palæocene," used by Schimper, has been applied to lower or even middle Eocene floras, and its continuance would therefore involve much confusion. While a special designation is a necessity for infra-Eocene deposits, the term Oligocene is, upon plant evidence, wholly unnecessary. From Eocene to Miocene there is no break whatever, and an Oligocene formation has to be created, so far as plants are concerned, from even distinctly middle Eocene formations.

REVIEWS.

ANIMAL CHEMISTRY.*

IT is with pleasure that we welcome the present work, which seems well designed to meet the want of a good modern work on animal chemistry, and well fitted to form a companion volume to Miller's "Elements of Chemistry." The author has divided his work into five parts, as follows:—I. General; II. Organs, fluids, and processes concerned in digestion, &c.; III. Nutrition, or "work and waste"; IV. Other organs, tissues, and fluids of the body; V. Chemical and philosophical subjects.

Under the first head Mr. Kingzett gives a brief sketch of the early history of the subject, lightly touches on the connection between vital and chemical phenomena, and concludes with a short statement of his views on the relations between modern chemistry and physiology and pathology. In the second part (pages 47–123) we find an account of the chemistry of the saliva, gastric juice, bile, liver, &c., giving a brief account of the principal normal and abnormal constituents. In the third part (pages 123–263) under the general head of nutrition, a fuller account is given of the chemistry of the chyle, lymph, blood, urine, sweat, &c., of the process of alimentation and respiration, and of the connection of animal heat, vital force, and muscular oxidation, together with a brief sketch of the chemical dynamics of the body. Part IV. (pages 263–359) is devoted principally to the chemistry of the constituents of the brain; but concludes with a brief notice of the constitution of the bones, teeth, milk, pus, &c. Finally, the last part, V., may be divided into two portions: the first (pages 359–416) deals at some length with the chemistry of the albuminoids, and ends with an outline sketch of the carbo-hydrates and fats; the second portion is miscellaneous, and touches on the diverse subjects of fermentation, putrefaction, germ-theory of disease, antiseptics, "sanitas," physiological action of different chemical substances on character, as examplified by the genius and the fool, on the teaching of animal chemistry, and on different researches which ought to be undertaken. The work ends with a good index and list of authorities.

We are decidedly of the opinion that the present work will form an important contribution towards the advancement of our knowledge of

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* "Animal Chemistry, or the relations of Chemistry to Physiology and Pathology." A manual for medical men and scientific chemists. By C. T. Kingzett, F.C.S. 8vo. London: Longmans, Green & Co., 1878.

animal chemistry, and that it will prove a valuable addition to the literature of this branch of science. It is true that we cannot agree with all the conclusions arrived at in this work, and in instances we entirely disagree with the author's criticisms on the researches of other workers in the same field, but this is no more than might be expected in the case of an author with the decided and original views of Mr. Kingzett. The author states his ideas with clearness and force, and they are such as will well repay careful examination and consideration. In several instances he has succeeded in throwing much light on what previously were very doubtful questions, and thus earns the gratitude of those working on the subject. In several respects, indeed, we could have wished that the work had been rendered more complete. In more than one instance we have been disappointed in finding that important subjects had been merely glanced at, or were passed over with a bare reference when the work might have very well embodied some of the information now scattered about in isolated researches. In this respect the present work is not likely to take the place of a standard manual, which ought to contain a careful synopsis of all that is known on the subject. To a certain extent Mr. Kingzett's work possesses more of the character of an elaborate essay than of a treatise, both in its style and in its objects. At times more attention is devoted to criticisms, the opinions of different investigators, than to summarising the facts resulting from their investigations; although to us it would seem that these last were essential to the completeness of the volume.

The work presupposes a certain amount of chemical knowledge on the part of the reader, although no more than might reasonably be expected. Any additional information which may be required for special sections will be found supplied in the work. Mr. Kingzett rather discountenances the recent developments of theoretical organic chemistry. He has not introduced them, therefore, into the present work, which thereby gains in simplicity, if it loses somewhat in power. It is a work which we have no hesitation in recommending to all those who may require a knowledge of the subject of animal chemistry. To medical men we feel sure it will prove of great service; and to young scientific chemists it will suggest a field for invaluable researches.

PLEASANT WAYS IN SCIENCE.*

MR. PROCTOR has here collected eighteen essays, taken chiefly from the "Contemporary Review," the "Gentleman's Magazine," the "Cornhill Magazine," "Belgravia," and "Chambers' Journal." One is the substance of a lecture delivered at the Royal Institution, in May 1870.

The subject of the first is the Sun; of the second "drifting" light; of the third "star drift." The rest seem miscellaneous, and contain Mallet's "Theory of Volcanoes," "Towards the North Pole," a narrative of the Arctic Expedition of 1876, and an account of the tremendous wave which, in 1876, swept

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* "Pleasant Ways in Science." By Richard A. Proctor. Sm. 8vo., London: Chatto & Windus, 1879.

the Pacific Ocean from Peru northwards, and which is shown to be due to an upheaval of the ocean bed. Then we have our old friends the kraken and sea-serpent: followed by some "marvels in telegraphy," and the phonograph. The gorilla, food, ozone, dew; the levelling power of rain, and ancient Babylonian astronomy, complete the list.

The book is essentially light and readable, suited to the "many who wish to learn about scientific discoveries without special labour, for which some have perhaps little taste, and many scant leisure."

Works of this kind are especially valuable for filling the smaller gaps in busy men's time to some profit, and without strong mental effort. A detached essay can be read, when a treatise would be neglected. Mr. Proctor's lucid style of writing materially aids in the mental assimilation of his topics. No doubt small inaccuracies may be found here and there; but the book hardly deserves the fastidious and somewhat pettish tone of general condemnation with which, under well-known initials, it has elsewhere been received.

W. H. Stone.

THE EUCALYPTUS.*

ALIKE the scientific and unscientific reader may profit by a perusal of this excellent manual of eucalyptus-planting. Its author, from his position as Agricultural Inspector to the Government of Algeria, writes with authority, and adds to his own valuable experience a large number of facts bearing upon this most important and interesting question. The *Eucalyptus globulus* (or Australian blue gum tree) is not only a fast-growing and ornamental garden tree; it is not only possessed of anti-febrile qualities to a remarkable degree; but it is moreover very productive from an economic and commercial point of view, affording a great variety of chemical and medicinal products, besides timber of excellent quality and astonishingly rapid growth. The plan of M. Certeux's little work is judiciously adapted to the wants of his readers. There is a general catalogue of *Eucalypti* to begin with; and following this is a classification of those species with which growers are most familiar, each being considered from various points of view. Thus we have only to turn to the index to find out which especial tree thrives in plains, marshlands, or sandy soil; which is richest in essential oils and tannin; which is the most effective in sanifying unwholesome districts; and which most speedily yields grateful shadow. We have also abundant information upon the various methods of planting and cultivating the tree, and the cost, as illustrated by the largest and most important experiments that have yet been tried, namely, those in Algeria. Lastly, we have a list of the multifarious, economic, pharmaceutical, and artistic preparations from *Eucalypti*, with many other details that the least scientific reader must find both interesting and instructive.

When we consider that M. Certeux's classified catalogue embraces 216 species or varieties, we shall see the difficulty of the task he has performed

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* "Guide du Planteur d'Eucalyptus." Par A. Certeux. Paris: Challamel aîné.

so conscientiously and evidently *con amore*; the subject exercising an extraordinary fascination upon all who take it up.

To show how much attention has been given to the eucalyptus in its adopted home of Algeria, we will only mention one fact. In 1876 there were no less than 119 species growing in the experimental plantations of El-Alià belonging to one chemist alone, M. Cordès. This, probably the largest collection in the world, is due entirely to private enterprise, and too much praise cannot be accorded to such services rendered to science in the teeth of all kinds of difficulties and disadvantages. All who have made themselves familiar with French colonization in Algeria must admire the public spirit displayed within the last twenty years on behalf of the *réboisement* or replanting of the country, a measure so necessary alike on sanitary and economic grounds. Already the effects of this movement are being felt in many districts, and M. Certeux points out other benefits likely to accrue from the young eucalyptus forests.

Take the prevalence of ophthalmia in treeless countries, for instance. We all know that the glitter and blaze of the Egyptian or Algerian atmosphere account for the painful maladies of the eyes and blindness so common in these countries. Plant the fast-growing, umbrageous eucalyptus trees, and the causes of the evil would disappear. Again, we have here many novel and interesting facts for the bee-keeper. The eucalyptus, in consequence of its abundant flowers, attracts the bees, and wherever it has been planted the bee has followed it; the species best adapted for apiculture being the *E. globulus, E. gigantea, E. odorata, E. roseata, E. amygdalina,* and *E. siderostylus.*

Many valuable preparations have already been added to the pharmacopœia by the essential oils, bark, and leaves of this tree, and there can be no doubt that others await discovery. M. Certeux's manual will prove equally useful to the scientific student therefore, since he gives not only a list of the different medicines and medicaments, but an analysis of each. He also gives extracts from the treatises of M. Cloëz and other analytical chemists who have made the eucalyptus an especial study. On the whole, this is a little work botanists, agriculturists, and the lovers of natural science generally will do well to consult, and it has the advantage of containing a vast amount of information in a small compass.

THE GEOLOGY OF IRELAND.*

WITH Prof. Ramsey's "Physical Geography and Geology of Great Britain," Mr. Horace Woodward's "Geology of England and Wales" and Prof. Hull's "Physical Geology and Geography of Ireland," it might be thought that the ordinary reader had an abundant supply of information upon the structure of these islands, but an examination of Mr. G. H. Kinahan's "Manual of the Geology of Ireland" will show that upon this part of the kingdom at any rate there was still a good deal to be said. Mr. Kinahan in his treat-

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* "Manual of the Geology of Ireland." By G. Henry Kinahan. 8vo. London: C. Kegan Paul & Co., 1878.

ment of the subject goes into more local detail than Prof. Hull, his work in this respect exhibiting some resemblance to the second of those cited above, and by this means he succeeds in producing a very vivid picture of the geological structure of Ireland. In some points of stratigraphical geology he differs in opinion from the survey of which he is a member—the Lower Silurian rocks of the survey are for him Cambro-Silurians—the Old Red Sandstone of Ireland, at any rate, follows the Yellow Sandstone into the Carboniferous series; and his treatment of the unmistakable members of the latter differs somewhat from that which must be regarded as orthodox from a survey point of view. The author does not, any more than Prof. Hull, recognise the presence of Pre-Cambrian rocks in Ireland, so that we must wait until Mr. Hicks can make an exploration of the Sister Isle, before we can hope to hear of the existence of Irish Pebidians, Dimetians, and Arvonians.

In his first section Mr. Kinahan treats of the Sedimentary formations; his second is devoted to the metamorphic and eruptive rocks, upon the nature and production of which, as is pretty well known, he holds certain opinions of his own. His views with regard to metamorphism are stated as follows: "Metamorphic and eruptive rocks. . . are intimately connected, all being indirectly due to Metamorphic Action. . . . One kind of metamorphism is *Regional*, or extends over large areas. The rocks affected by it seem to have been under the influence of intensely heated water or steam which, as it were, stewed them, from which the action may be called *Metapepsis*. Another kind is merely *Local*, its effects being only found immediately adjoining intruded masses of rocks, or in the vicinity of vents where gases, steam, or other products of vulcanicity found egress. When typical, this kind of metamorphism produces in the rocks an appearance as if they were baked, from which it may be called *Paroptesis*. It is not, however, always typical, as many of the altered rocks must have contained moisture, which, when heated into steam, would give results more or less similar to Metapepsis, except that the action would be confined to limited areas. . . . There is a third class of Metamorphism which is also local. It is due to the introduction and action of chemical substances from without; it has been called *Methylosis*. . . . Metapeptic action is the metamorphism that is most interesting to the geologist, as it is by the extreme action of it that eruptive rocks have been formed." From this point of view Mr. Kinahan forms a classification of the Eruptive and Metamorphic rocks, in accordance with which he treats those which occur in Ireland in the same local detail as the sedimentary deposits.

A third section treats of the superficial accumulations and includes not only a discussion of the Drift and Glaciation of Ireland (the details of the latter do not appear to be quite so well settled in Mr. Kinahan's mind as in those of some other observers), but also an account of ancient sea-margins, great deposits, and the pre-historic remains of man, upon which Mr. Kinahan has naturally a good deal to say. We have here also a chapter on the Post-Pliocene Mammalia.

Section IV. treats of the physical features of the country; and Section V. of its economical products in the shape of minerals, building and other stones, and mineral manures. This last section is of much practical importance, and its

value is increased by a list of mineral localities arranged in counties, with indications of the particular form of mineral wealth to be obtained in each of them. This section closes with a short article on the water supply. In an appendix we have a glossary of Geological and Celtic terms. The book is illustrated with a good many woodcuts of sections and scenery, most of which are very good, and with some plates of fossils, the figures in which, although rather rough, are characteristic. There is also a nicely coloured geological map of Ireland.

In this little book Mr. Kinahan has certainly succeeded in producing one of the most original and thoroughgoing treatises on local geology that it has even been our good fortune to peruse, and geologists are deeply indebted to him for giving them so admirable a guide to the geology of his native country. It is rather sad to see that the book is dedicated to Sir Richard Griffith, whose death must have taken place almost at the time of its publication.

ETNA.*

ALTHOUGH the largest volcano of Europe, and the one which, according to history and tradition, has been the longest in action, Etna seems to have achieved but scanty fame in this country, and the surprise which the author of the little volume now before us experienced on finding that there was no special work upon this mountain in the English language was certainly justified. Its younger sister on the continent of Italy is much better off in this respect, owing, no doubt, in part to its proximity to Naples and to the comparative facility with which its summit can be reached; in part also to the celebrity attaching to it as at once the destroyer and preserver of the two cities of Herculaneum and Pompeii. The fabled prison of the rebellious giants and forge of Vulcan has, however, received more justice at the hands of foreign writers, among whom Carlo Gemellaro and Sartorius von Waltershausen stand pre-eminent, as the authors of special "Ætnographies," whilst our own countryman the late Sir Charles Lyell has contributed in no small degree to the explanation of the phenomena presented by the mountain. In fact, as Mr. Rodwell tells us, "later writers usually quote Von Waltershausen and Lyell, and do not add much original matter;" and, considering the quality of the work done by those distinguished geologists, this may be taken rather as a compliment to the judgment of the later writers, of whom our present author is one. So far as we can see Mr. Rodwell in his little volume (which is an expansion of his article "Etna," in the "Encyclopædia Britannica") adds little to the stock of knowledge previously possessed by geologists as to the structure of the mountain, although it would be unfair to stigmatise his work as a mere compilation, seeing that while he cannot claim that it is the product of original research, the author nevertheless in bringing it together had the advantage of a personal acquaintance with the locality under consideration. Mr. Rodwell has in point of fact produced an excellent and readable popular account

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* "Etna: a History of the Mountain and of its Eruptions." By G. F. Rodwell. 8vo. London: C. Kegan Paul & Co., 1878.

of the great Sicilian volcano. He opens with a history of the mountain, or rather of the knowledge of the mountain, then describes its physical features in detail, including in this category the peculiarities of distribution of animal and vegetable life upon its surface; gives an account of his experience of an ascent to the summit, which includes many useful hints for those who may desire to follow in his footsteps; and finally notices the various towns situated on the slopes of Etna itself, which are interesting in many respects, and appear to be in a flourishing and increasing condition. The fifth chapter contains a chronological account of the recorded eruptions of Etna, of which the author notes seventy-eight, the earliest in the time of Pythagoras, B.C. 525, the latest in 1874. The earlier traditions, which would carry back the activity of the mountain as far as the year 1226 B.C., are mentioned by Mr. Rodwell, but not regarded as sufficiently authentic to be relied on. In most cases, but especially with reference to the more violent eruptions, the phenomena manifested are briefly described. In the sixth chapter the author descants, briefly, as may be supposed, upon the geology and mineralogy of the great volcano, and here we find references to recent investigations by Professor Silvestri, and to the results of original researches, supplemented by an appendix by Mr. Frank Rutley on the microscopic characters of the lavas of B.C. 396 and A.D. 1535, 1603, and 1689. The constituents of these lavas are "plagioclase, augite, olivine, magnetite, and, in some cases, sanidine—possibly titaniferous iron—and in some, if not in all, a slight residuum of glass;" and Mr. Rutley remarks upon the close similarity of structure presented by these lavas, the first and last of which are separated by an interval of more than 2,000 years. Drawings showing the microscopic structure of these two lavas are given. The other portions of the book are fully illustrated with drawings and maps, some of the latter coloured.

SILURIAN FOSSILS OF GIRVAN.*

THROUGHOUT the South of Scotland, wherever fossiliferous rocks occur, they are so twisted and twirled about that the attempt to arrive at any definite conclusion as to their succession is a matter of no small difficulty. One of the best examples of this is to be found in Mr. Lapworth's recent paper on the rocks of the Moffat district, the extreme complication of which could only be elucidated by years of work upon scattered exposures of beds containing graptolites. Still further west, in the district of Girvan, in Ayrshire, the Silurian rocks are almost equally confusing. Great masses of eruptive rocks have been pushed up through the sedimentary and metamorphic beds, and the latter have, in consequence, been thrown into several folds within the distance of a few miles. By the action of faults and of rivers cutting down into these deposits the fossiliferous Silurian rocks are exposed here and there; but the exposures are so unconnected that the correlation of the

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* "A Monograph of the Silurian Fossils of the Girvan District, in Ayrshire." By H. Alleyne Nicholson, M.D., &c., and Robert Etheridge, Jun., Fasciculus I. 8vo. London and Edinburgh: Blackwood & Sons, 1878.

various deposits can only be effected by a thorough investigation of their fossil contents.

This is the task which Messrs. Nicholson and Etheridge have set themselves to fulfil, with the aid of a grant from the Royal Society. A considerable number of fossils had already been described from the Girvan deposits; but, as a matter of course, in many cases the descriptions were unaccompanied by those precise stratigraphical details which alone could render them available for the interpretation of the beds; and the authors were under the greatest obligations to Mrs. Gray, of Edinburgh, whose collections, amassed with the greatest care, were placed freely at their disposal. Accordingly their monograph of the fossils, of which the first fasciculus is now before us, is stated on its titlepage to bear special reference to the fossils contained in the "Gray collection."

In this first fasciculus the authors describe the Rhizopoda, corals, and trilobites which have been collected from the Silurians of Girvan, and which, especially in the first two groups, include many exceedingly interesting forms, a great number of them representing species and even genera previously unrecognised. The study of the corals leads the authors to certain general views as to the age of the deposits from which they are derived, and they distinguish the following local divisions:—

1. The Craighead limestone, which contains a peculiar set of corals, indicating Lower Silurian age, and having an American facies, leading the authors to regard it as corresponding to the upper part of the Trenton Limestone, or the base of the Cincinnati and Hudson River formations of North America.

2. The Mulloch Hill beds, containing *Heliolites interstinctus* and other fossils, indicating an age equivalent to that of the Upper Llandovery.

3. The Penkill beds, with the above *Heliolites*, *Halysites catenularius* and a species of *Calostylis*, indicating a position in the lower parts of the Upper Silurian series (Wenlock?).

4. The Shalloch Mill beds, containing *Favosites gothlandicus* and *Alveolites Labechei*, ummistakably indicating Upper Silurian age.

5. The Balcletchie beds, coarse, fossiliferous volcanic ashes, with very few corals, which the authors suppose to be nearly of the same age as the first mentioned series.

It will be seen that although the materials for forming a notion of the stratigraphical relationship of these deposits are still scanty, certain definite points are already laid down, and in all probability the authors will be able, before concluding their labours, to arrive at satisfactory results. Under any circumstances, however, even if the extant material be insufficient for this purpose, they will leave to future investigators of this interesting district a great mass of most valuable material admirably worked up. It is, in fact, impossible to speak too highly of the conscientious and careful manner in which Messrs. Nicholson and Etheridge have performed their self-imposed task; but their style of work is so well known to all palæontologists, that we may spare ourselves the trouble of seeking for complimentary phrases in which to express our appreciation of their present effort. The work is illustrated with nine plates of fossils, lithographed by Mr. Berjeau, partly from nature, partly from the drawings of Dr. Nicholson, and of these we

can only say that they are equally deserving of praise with the literary part of the book. As a whole this fasciculus is a piece of palæontographical work of the very highest character, and we trust that the authors may be encouraged, by the reception it meets with from their *confrères* and the public, to complete it in the same style.

WEST YORKSHIRE.*

FOR the geologist the great county of Yorkshire must be looked upon as classical ground. In 1829 John Phillips, in the first part of his "Illustrations of the Geology of Yorkshire," which treated of the Yorkshire coast, gave the earliest practical illustration on an extended scale of the application of the principle of determining strata by their organic remains, which had just been promulgated by his uncle, William Smith; and the county has ever since been noted for the great amount of attention which has been devoted to its exceedingly interesting geological structure. In 1836 Phillips completed his work on the geology of his adopted county by the publication of a second and much larger part, in which those portions of Yorkshire lying to the west of the great vale of York were most elaborately described; and at that early date no other county in England could boast of having its geology so thoroughly worked out.

This pre-eminence has doubtless been considerably diminished in the lapse of more than forty years, partly by the progress of individual research, and partly by the action of the Geological Survey in other counties; and unquestionably by both these agencies some modifications have been introduced in the geological idea of Yorkshire as originally drawn by Phillips. That geologist had, indeed, nearly prepared for publication a new edition of his first part (subsequently brought out under the care of Mr. Etheridge), embodying the results of investigations which had been made by others upon the eastern part of Yorkshire. The work of Messrs. Blake and Tate upon the Yorkshire Lias is one of great importance; and the number of memoirs published in various periodicals upon the secondary strata of the county is very great.

By its geological construction Yorkshire is naturally divided into two very distinct parts. Right down the middle of the county runs the wide vale of York, with its Triassic beds, separating the secondary rocks of the North and East Ridings from the palæozoic formations of the west of Yorkshire, as effectually as if the former constituted an island cut off by an arm of the sea. Since the completion of Phillips' "Illustrations" the western division has received no small share of attention from geologists; in fact, the authors of the book before us give a list of nearly 500 separate works and scattered memoirs relating to the geology and physical geography of the region of which they treat, and which includes not only some of the most interesting scenery in England, but also extensive deposits of coal, and many great

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* "West Yorkshire: an Account of its Geology, Physical Geography, Climatology, and Botany." By James W. Davis and F. Arnold Lees. 8vo. London: L. Reeve & Co., 1878.

industrial towns which have sprung up in consequence of the vicinity of abundant fuel. We must remark, however, that Messrs. Davis and Lees confine their attention in this book exclusively to the West Riding of Yorkshire, leaving out of consideration the western portion of the North Riding, which nevertheless forms a continuous whole with the district investigated by them. This seems to be a pity; but perhaps the authors might urge in defence of the course they have adopted that their western boundary is as arbitrary as their northern one, and that they might with equal justice be called upon to carry their researches into the neighbouring counties of Lancashire and Westmoreland. So let us be thankful for what we have got and are promised.

It appears from the authors' statements that they had hoped to embrace in a single volume all that they have to say on the geology, physical geography, and botany of the West Riding of Yorkshire. In this expectation they have been disappointed, and this first instalment—which, we presume, may be regarded as constituting half the entire work—includes the geology of the district worked out by Mr. J. W. Davis, and the physical geography and botanical topography in accordance with the various drainage areas, by the combined labours of both authors.

As the eastern boundary of the Riding is formed by the Ouse and Humber it includes a considerable portion of the Triassic formation of the great central valley, but the great mass of the district is composed, as above stated, of Palæozoic rocks. In the north-west corner the Silurian rocks, which form the chief part of the adjoining county of Westmoreland, occupy a small space, and are exposed in considerable thickness in various sections; along the eastern border of the Palæozoic area stretches a great band of Permian rocks; while the remaining space is occupied by different members of the great Carboniferous group, here very fully represented. All these formations, with their subdivisions, as well as the Trias of the vale of York so far as it falls within the Riding, and the post-Tertiary drifts and other more modern deposits which cover so much of the latter and occupy parts of the valleys among the older rocks, are described by Mr. Davis in accordance with the most recent investigations, checked and corrected by his own researches especially among the coal-measures. His description of the geological structure of West Yorkshire is illustrated with an excellent coloured geological map and twenty-one plates, sixteen of which represent actual sections in black and white, while the remainder contain coloured diagrammatic sections of different parts of the area. Mr. Davis thus furnishes the student with an excellent *résumé* of West Yorkshire geology, particularly well adapted to serve as a guide in its practical investigation, especially as his lists of the fossils obtained from the different formations are very full and complete.

In the second part, which is the joint production of both authors, the surface conformation of the district is treated of, with special reference to the distribution of its native plants, which are here noticed in accordance with the river drainage-basins in which they occur. This section of the work is illustrated with a map of the Riding, in which the different drainage areas are distinguished by colours. The richness of the flora appears from the fact that 1,189 species of flowering plants, ferns, and fern-allies have been

found growing within the district, of which 904 are regarded by the authors as truly indigenous; whilst 319 mosses, 232 lichens, 75 liverworts, and 388 fungi have also been recorded as natives. To the student of botanical topography this work of Messrs. Davis and Lees, with its descriptions of physical conditions and lists of peculiar plants, cannot fail to be of interest; while the latter will be most welcome to collecting botanists, whose numbers are by no means inconsiderable among the handicraftsmen of the West Riding. The second volume, which will treat of the climatology and flora of the Riding and their connection, will add very considerably to the value of this treatise on its botanical topography.

THE ART OF SCIENTIFIC DISCOVERY.*

THE necessity for works of a constructive and methodic character, in an age occupied with the incessant gathering of facts, has already been adverted to in these pages. What Mr. Skertchley proposed to do for cosmogony Mr. Gore attempts in the cause of human thought. He proposes "to describe the nature of original scientific research, the chief personal conditions of success in its pursuit, the general methods by which discoveries are made in physics and chemistry, and the causes of failure; and thus to elucidate as far as possible the special mental conditions and processes by means of which the mind of man ascends from the known to the unknown in matters of science."

As a known expert in physical research he has an undoubted right to contribute to the long list of such works which have sprung from the philosophic mind in various ages. First among these comes the "Organon" of Aristotle, a treatise to which its shrewd and practical author gave the familiar name, inasmuch as it was to be a "tool" or "implement" in the hands of mental workers, by means of which they should dig out truth. It once and for all showed the capabilities of the deductive method of logic in averting error. Many ages after arose a New Organon, a tool adapted to the changed aspect of men's minds, and the dawning of the inductive method, carried only of late to its highest development in the great work of Mill.

But perhaps the nearest kinsmen of a book like this are the "Regulæ Philosophandi" of Newton; near, because they too were concerned with physical inquiry; and nearer still because as rules they presupposed an art, and did not aim at the foundation of a new science.

There can be no doubt, as the writer says, that "an art of scientific discovery is much more possible now than it was in the time of Lord Bacon, and is fast becoming more so, and that the process of scientific discovery can even now be much more completely reduced to order and rule than is generally supposed." It depends on "a combination of experiment and logical inference," the latter of which has been "insufficiently studied, the success achieved having, therefore, been attributed too much to accident, to

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* "The Art of Scientific Discovery, or the General Conditions and Methods of Research in Physics and Chemistry." By G. Gore, LL.D., F.R.S. Sm. 8vo, pp. 648. London: Longmans, Green & Co., 1878.

strong imagination, and to exceptional natural ability; too little to the less brilliant qualifications of steady thought, self-development, industry, and perseverance."

The book is in five parts, the first containing a general view of the subject; the second, general conditions of scientific research; the third, personal preparation for research; the fourth, actual working in the art; and the fifth, various special methods of discovery, classified, and illustrated by numerous examples.

It is impossible in a short notice to go through the mass of matter contained in over 600 pages; but attention may be drawn to the remarks in Part II. on "unexpected phenomena," on "unexpected or accidental discoveries," in which, quoting Whewell, the writer lays down the rule that "no scientific discovery can with any justice be considered due to accident. In whatever manner facts may be presented to the notice of a discoverer, they can never become the materials of exact knowledge, unless they find his mind already provided with precise and suitable conceptions by which they may be analysed and connected." Very much the same remark was quaintly made by Aristotle in the aphorism that "All knowledge comes out of things known before."

The whole third part is deserving of study by those in charge of promising and intelligent pupils. It will tend to lighten the heavy responsibility resting on them. The following passage deserves quotation: "To be born before the time is almost as unfortunate as to be behind it. All original scientific investigators must, however, be more or less in advance of their time, otherwise they cannot be original at all. A scientific investigator may be before his age in more ways than one. Thus he may imagine and publish advanced and true hypotheses, the complete proof of which cannot be discovered until a later period. This was the case with Avogadro, and his hypothesis that equal volumes of different gases contain equal numbers of molecules. It is probably the case with some existing eminent men and their hypotheses. Or he may, as Galileo did, and Bruno shortly before him, publish his views and the proofs of them at the same time. But in either of these cases, if the views he publishes or even appears to hold, conflict with, or only appear to conflict with, the current creeds and unproved dogmas of theological belief, his character is privately attacked, and the minds of female members of his family (who can rarely understand science, but are easily influenced by feeling and religious emotion) are perverted, and his home happiness injured. In other instances his means of living are diminished. It is worthy of notice that every great pioneer of science, including even Newton himself, has been and still is accused by the ignorant of holding false opinions and beliefs, even in cases where those beliefs have been proved to be true. Retreating dogmatism continually says to the scientific investigator, 'Thus far shalt thou go, but no farther,' but science keeps marching on."

Part IV. describes the selection of a subject of investigation, the mode of conducting it, the value of many and various experiments, and of close measurements, the classification and explanation of results.

The fifth part is more miscellaneous. Empirical methods of discovery, the extension of neglected or undeveloped parts of science, the use of new instru-

ments, the investigation of likely circumstances, the testing of hypotheses, methods by comparison of known truths, by calculation based on known truths, and many other topics, are in turn considered, always with clear perception and abundant apposite illustration. We must, however, go back to the first few pages for a confession of faith which gives its savour to the whole work. It is there affirmed that "one of the most perfect ways in which we can show our obedience to the Creator and our feeling of thankfulness for the numberless blessings we enjoy, is to develop new truths, and thus to hand down a larger share of their good results to our successors. One of the greatest bequests man can make to his fellow-men is the discovery of a great general truth. Discoveries are living waters, fresh from the fountain of intelligence."

W. H. STONE.

THE STEAM ENGINE AND RAILWAYS.

WE have had many books, popular and technical, written on the steam engine; but hackneyed as the subject may appear, a perusal of Professor Thurston's little volume * just published will show that there is still plenty of life in it. In this excellent treatise, which forms a part of the "International Scientific Series," the author adopts a rational historical treatment of his subject. He commences with the period of speculation, extending from the earliest recognition of the motive power of steam by Hero and other Greek philosophers to the time when the Marquis of Worcester first succeeded in applying this power to the performance of actual work; and then describes the efforts made in this direction during what he calls "the first period of application." In this section of the subject we find the steam engine acting as a simple machine, with a single application to the business of pumping water, which it effected with more or less success. These rude inventions (among which we find engines worked by alcohol and gunpowder) performed a certain amount of work, and although their defects were serious, the efforts of mechanicians to improve them led to the employment of many useful contrivances. As Professor Thurston says: "The steam engine, as a simple machine, had been given as great a degree of perfection by the successive improvements of Worcester, Savery, and Desaguliers, as it was probably capable of attaining by any modification of its details," and "it now only remained for the engineer to combine known forms of mechanism in a practical machine, which should be capable of economizing and conveniently utilizing the power of steam through the application of now well-understood principles, and by the intelligent combination of physical phenomena already familiar to scientific investigators." In other words, the steam engine had to become "a train of mechanism," and it is to the history of its development in this form, commencing with the efforts of Newcomen in 1705, that the greater part of the present volume is devoted. The author traces most clearly and admirably

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* "A History of the Growth of the Steam Engine." By Robert H. Thurston, A.M. Sm. 8vo. London: C. Kegan Paul & Co., 1878.

the progressive steps by which the gigantic power of steam has been made subservient to human needs, until at length its applications have become so general that we have ceased to marvel at what are really the most wonderful triumphs of mechanical skill. From the time when Watt virtually completed his improvements of the steam engine, about the year 1780, down to 1850, constitutes what Professor Thurston calls the "second period of application," during which the strength of the tamed giant was being utilised in the most various ways; and the history of this development of the application of steam to useful purposes, and especially in locomotion, both by land and water, is given in considerable detail. Then follows what is denominated "the period of refinement," extending from 1850 to the present day—a period during which constant modifications and mechanical improvements have been introduced into the steam engine to fit it for special purposes. The author concludes with two chapters on the philosophy of the steam engine, embracing the physical principles involved in its construction and working, which will be found of great interest and importance. The work is admirably illustrated throughout with woodcuts, and is undoubtedly the best general popular treatise on the subject that we possess.

Professor Thurston naturally devotes a considerable share of attention to the development of the railway system, which must be regarded as the most potent agent in that revolution that has taken place in the social condition of civilized nations. Thackeray considered that in this country, at any rate, society passed out of its old into its new development during the reign of George III.; but it has always seemed to us that the old-world conditions prevailed continuously, under gradual modification, of course, until a later date, and that the great revolution in all our habits and modes of thought may be held to date its origin from the introduction of the railway system and of ocean steamers, say with the inauguration of the Manchester and Liverpool line in 1830, less than fifty years ago. We know what has taken place since then, within the lifetime of a middle-aged man—how completely all the habits of people have changed—how enormously all the capitals of Europe and the great centres of industry have increased—how the electric telegraph, springing out of the needs of the railway system, has entirely changed the nature of all business transactions, and brought nearly the whole world close together—and how great a progress has been induced in a thousand other directions, which may be referred, indirectly perhaps, to the same influence.

Mr. Parsloe, while going to some extent over the same ground as Prof. Thurston in his account of the first steps in this gigantic innovation, may virtually be regarded as taking up the story where the Professor leaves it, in his little volume (just published) on "Our Railways."* After some interesting sketches illustrating the old and new systems of travelling, and the difficulties and opposition which the introduction of the latter met with, he proceeds to give a history of the development of the railway system in this country, the construction of railways, the mode in which the existing iron

* "Our Railways: Sketches Historical and Descriptive, with Practical Information as to Fares and Rates, &c., and a Chapter on Railway Reform." By Joseph Parsloe. Sm. 8vo. London: C. Kegan Paul & Co., 1878.

network has grown up, the use of signals, gauges, brakes, &c., and then describes the whole method of railway management, tickets, luggage, express trains, the official staff of a railway, the system of accounts, and management of the clearing-house. He discusses these and many other matters connected with railways and railway travelling, legislation, and reform, and altogether presents his readers with a mass of exceedingly interesting and practical information on the subject, which cannot but be useful in the present day, when, considering the mode in which the railway system has come to pervade our whole lives, it is of great importance that the public should have some idea of the working of this mighty agent of change. In the closing chapters of his valuable little book Mr. Parsloe briefly notices the development of railways on the continent of Europe and in North America.

THE TELEPHONE AND PHONOGRAPH.*

SO many novel applications of electrical science have lately been announced from the other side of the Atlantic, that the reader of such a journal as the *Scientific American*, unless indeed he happen to be a specialist, is likely enough to get bewildered by the multiplicity of inventions that are forced upon his attention. Mr. Prescott has therefore done well to collect into a single volume much that has been written on these subjects, especially on the various forms of telephone. The latest American improvements in telephony are here described, and amply illustrated. In writing on such subjects it is difficult to avoid discussing the delicate question of priority of invention, and this question is especially prominent in connection with the Bell telephone. The evidence here adduced tends to show that the familar form of instrument known as the "handle telephone," generally attributed to Prof. Bell, was really devised by Dr. Channing and Mr. Jones in Providence, Rhode Island. The lecture delivered by Prof. Bell to the Society of Telegraph Engineers in this country is reproduced *in extenso*, by Mr. Prescott, but not without notes which slightly affect some of the lecturer's statements by pointing out the part which Mr. Elisha Gray has played in the development of telephony.

Although the phonograph is an instrument which is not based on electrical principles, it is very properly placed by the side of the telephone, and described in detail by Mr. Prescott. We find no mention, however, of either the microphone or the megaphone. On the other hand, the electromotograph of Edison comes in for description; and an interesting chapter is devoted to the subject of Quadruplex telegraphy. Curiously enough, another section is given up to the description of electric call-bells; while the work concludes with a chapter on the electric light. So much, however, has lately been written on electric illumination that the chapter does but scant justice to the subject, and represents very imperfectly the present condition of the question. Nevertheless some attention is given to the pro-

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* "The Speaking Telephone, Talking Phonograph, and other novelties." By George B. Prescott. 8vo. New York: D. Appleton and Co., 1878.

duction of light by the incandescence of platinum and of iridium; and if rumour be true-tongued it is an alloy of these metals which Edison employs. No mention, however, is made of Edison's light; nor could this be expected, as we presume the volume was printed before the scientific world had been startled by the mysterious paragraphs which have since been circulated on this subject.

While believing that Mr. Prescott's volume will be widely useful in offering a compact account of many recent electrical inventions, it should be mentioned that much of the book is made up of papers published elsewhere by Dolbear, Grey, Page, Du Moncel and other electricians. We should not object to this method of book-making if the reprints and quotations were always clearly indicated by inverted commas or other quotation-marks. Unfortunately, however, such indications are used but sparingly, and the reader is therefore often at a loss to know where the quotations end, and whether he is reading the editor's or somebody else's words. There is much convenience as well as honesty in the American editor's maxim—to render unto scissors the things that are scissors'.

DANGERS TO HEALTH.*

THIS is an excellent, albeit a very quaint book. It takes its origin in a lecture on Sanitation, delivered two years ago by Mr. Teale before the Leeds Philosophical and Literary Society. "The truth of the matter," says the writer, "is this, that having discovered and rectified, one by one, numerous defects of drainage in my own house, and in property under my charge, and having further traced illness among my patients to scandalous carelessless and gross dishonesty in drain work, I became indignantly alive to the fact that very few houses are safe to live in. Probably no work done throughout the kingdom is so badly done as work in houses, drains, and pipes, which is out of sight."

Now the quaintness and at the same time the force of the book is the way its author sets about remedying an acknowledged defect in our social administration. He does not attempt a treatise which would be read by few and understood by fewer. But he takes every form of defect, whether arising from ignorance or from dishonesty, and he chalks it up on the wall as a terror to evildoers. "The design," he says, "I have set before myself is this, to represent pictorially every important fault to which domestic sanitary arrangements are liable." The fifty-four plates thus form a sort of *Danse Macabre*; a half-humorous series, at which one first smiles, and then shudders. Each plate is the body of an occupied house skilfully dissected. The baby is in its cot, the maid is in the dairy, the kettle is boiling on the kitchen fire, the invalid in her bed, the meat is in the larder, the cotter is smoking at his door, the women are gossiping around the common pump. But the picture goes below the surface; the various faulty drains, and inlets

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* "Dangers to Health. A pictorial guide to domestic sanitary defects. 55 Plates with descriptions by T. Pridgin Teale, M.A., Surgeon to the General Infirmary, Leeds. 8vo. Leeds: Charles Goodall. London: Churchill.

of sewer gas are also shown in section, and from each source of infection curls a ghastly sinuous blue line ending in a forked tail like that of a goblin. We never see the body of this skeleton in the cupboard, this domestic demon, but his scorpion-like tail encircles meat, milk, invalid, and baby alike. If the thing were not strictly true it would be ludicrous, but every plate is given on sound authority; in most cases name and place are duly recorded as means of authentication. Mr. Teale is evidently terribly in earnest. He practically apologises for his method in the familiar quotation from Horace about eyes and ears. But his conviction is none the less contagious; and many a father or mother, after seeing this book (it does not need reading) will set his house in order, in terror of the Visionary Tail.

W. H. STONE.

PHYSICAL SCIENCE.*

THIS can hardly be called a new book, since the lectures on which it is founded were delivered as far back as 1874. But in matter as well as in style it retains a certain freshness which will long prevent its becoming an old one.

The method of its genesis is plainly indicated in the Preface. "The following Lectures were given in the Spring of 1874, at the desire of a number of friends—mainly professional men—who wished to obtain in this way a notion of the chief advances made in Natural Philosophy since their student days.

"The only special requests made to me were that I should treat fully the modern history of energy, and that I should publish the Lectures *verbatim*."

To the history of energy, its conservation, dissipation, transformation, sources and transference, after some introductory remarks, six Lectures are devoted. The transformation of heat into work gives origin to an excellent, lucid, and untechnical account of Carnot's ideas. Radiation, absorption, and spectrum analysis occupy three chapters; the conduction of Heat, with Fourier's Theory, furnish the eleventh; and the last two of the thirteen consider the intimate structure of matter.

Anything like mathematical analysis and even the abstruser parts of scientific terminology seem to be rigidly excluded; on the other hand illustrative experiments of the most apposite and striking kind are freely scattered through the book.

Sir William Thomson's high claims as a discoverer are justly insisted on.

The charm of the book is the extreme neatness with which difficult ideas are brought home to the reader, without any sacrifice of accuracy. A boy in the upper forms of a good school could follow every word, and would thence suck more intellectual nourishment than from "Science in a Teacup," or "Little Experiments for Little Nuisances," and the like.

W. H. STONE.

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* "Lectures on some recent advances in Physical Science." By P. G. Pait. M.A., &c. Sm. 8vo, pp. 337. London: Macmillan & Co., 1876.

TREES.*

WITHIN the last few months it has been our pleasant duty to notice two books by Mr. F. G. Heath—the "Fern World" and the "Fern Paradise," and we have now received a third volume by the same author, entitled "Our Woodland Trees," with which we are if possible even more pleased than with the writer's earlier works. It may at first appear, as it did to us, that a popular book on trees was unfortunate in making its *début* at a time

> "When all aloud the wind doth blow,
> And coughing drowns the parson's saw,
> And birds sit brooding in the snow,
> And Marian's nose looks red and raw."

But Mr. Heath is such a thorough enthusiast in his admiration of nature that his new book must, we feel sure, give delight to readers of almost any age, no matter how ungenial their surroundings may be. Though "the leaves have fallen, and lie scattered and dead on hill-side and in hollow, yet trees are lovely still," and Mr. Heath's agreeable and chatty descriptions of English woodland scenery seem actually to bring to one's senses the pleasant scent of the hawthorn and the honeysuckle, even in the midst of trees burdened with snow and glittering in the winter sunshine with pendant icicles. The plan of the book is extremely unpretentious, and it is perhaps to this that it owes its principal charm. Beginning with a brief explanation of the growth of a tree, its structure and its development, in the second part of the book Mr. Heath conducts us on "Some Woodland Rambles" in and about the New Forest; and here it is that he has so favourable an opportunity for the display of his intense appreciation of the charms of English scenery. Lending to the actual beauties of the New Forest an increased and more romantic charm are the innumerable historical associations which cluster around this early Norman hunting ground. And it would perhaps be difficult in the whole of England to select a spot more suitable for illustrating the beauties of English Woodland scenery than that which Mr. Heath has chosen. He speaks, too, with so keen and loving an appreciation of the charming scenery through which he wanders as to carry with him all but the most unsympathetic of readers: the ivy seems to cling kindly round his heart, and the sweet-scented honeysuckle to twine its branches around his imagination—he writes as it were in a bower of wild flowers, and the sweet scents of the forest and the meadow hover with balmy freshness around his pen. A third part of the book is devoted to "trees at Home," and pleads eloquently for the increased cultivation of Trees in the neighbourhood of our town and suburban residences; while the fourth part, occupying not far short of half the volume, consists of descriptions of British Woodland Trees—descriptions which are simple and untechnical, and which may be read and understood by all. While the woodcuts illustrating the earlier parts of the book having been admirably engraved from photographs, or from the drawings of such well-known artists as Harrison Weir

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* "Our Woodland Trees." By F. G. Heath. 8vo. London: Sampson Low, Marston & Co., 1878.

and Birket Foster, need no word of commendation from us, of the coloured plates illustrating the last portion of the work we must speak in high terms. These plates consist of examples of the leaves of common British trees, and have been carefully copied from photographs which reduced the specimens to half their natural size. Nearly all these illustrations are exceedingly good, and the author assures us that exceptional attention was paid to the faithful delineation of the venation; the representations of the conifers in particular are deserving of high praise.

FOLK LORE.*

THERE are few things more curious than the superstitious notions entertained in various places with regard to natural objects and phenomena, and Mr. Thiselton Dyer, taking due advantage of the interest attaching to the subject, has made a very amusing book out of "English Folk Lore." It would require a considerably larger volume, however, to do full justice to such a subject, and we find a good many things omitted which ought to have figured in it. Thus to take only two Shakespearian examples, Mr. Dyer quotes the reference in Hamlet to the disappearance of ghosts at the crowing of the cock, but omits the much more interesting statement that almost immediately follows:—

> "Some say that ever 'gainst that season comes,
> Wherein our Saviour's birth is celebrated,
> This bird of dawning singeth all night long:
> And then, they say, no spirit dares stir abroad:
> The nights are wholesome: then no planets strike,
> No fairy takes, nor witch hath power to charm;"

and again quoting, not directly, the reference to the "toad, ugly and venomous, no mention is made of the "precious jewel in her head," which, we cannot help thinking, many of Mr. Dyer's readers might like to know something about. There are several other references to the toad in Shakespeare which would be deserving of Mr. Dyer's notice when his book comes to a second edition, which we sincerely hope it may soon do. As he has no reference at all to cattle in his present volume, we can furnish him with the following curious superstition which we heard of a good many years ago from an old Essex woman. The cattle in the stalls, according to this authority, always bow their heads towards the east soon after midnight on Christmas morning; and she remembered having been taken, when a child, to witness the ceremony, *but, on the morning of old Christmas Day*, the cattle had resolutely refused to accept the new style. About half Mr. Dyer's book is devoted to the superstitions connected with natural objects, the moon, plants, and animals; the remainder treats of charms, births, deaths, and marriages, the days of the week, the months, and weather, &c.

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* "English Folk Lore." By the Rev. T. F. Thiselton Dyer, M.A. 8vo. London: Hardwicke & Bogue, 1878.

SCIENCE MANUALS.

IN these days of scientific school manuals and primers one would have thought that there was hardly room for a new set; but Messrs. Longmans, guided no doubt by a sound knowledge of their own business, have started a series of "Science Class Books," * under the editorial care of Prof. G. Carey Foster and Mr. Philip Magnus. Five of these little books are now before us, only one of which relates to a subject pertaining to the special studies of the editors, namely a treatise on "Hydrostatics and Pneumatics" by the second of them. This, the author tells us, "is intended for the use of those pupils in the upper forms of schools who have already acquired some elementary knowledge of the principles of mechanics," and even without this statement a very cursory inspection of the text sufficed to convince us that it was not intended for beginners, indeed we should hardly have thought that it was designed for the use of schoolboys at all. The information contained in it is of the most accurate and useful description, but from its extreme condensation and the constant use of mathematical formulæ, we should regard it rather as a useful memorandum book for somewhat advanced students than as an ordinary school-class work. We notice that in consideration of the recent discoveries of Messrs. Pictet & Cailletet, the author recognises a more intimate connection between the two branches of his subject than has, we think, usually been admitted.

Dr. M'Nab's treatises on the Morphology and Physiology of Plants and on Systematic Botany, are also intended specially for the use of the upper forms, but the author seems to have at the same time had in view the advantage of still more mature students; in fact, in his preface he specially announces his hope that they may "supply the wants of medical and other students." For these more advanced students they seem to be admirably adapted, and will also furnish an excellent guide for those who are commencing the practical study of plants. All these volumes are copiously and well illustrated.

Of Prof. Macalister's two zoological volumes we can hardly speak in such high terms. Zoology, especially when treated systematically, is so vast a subject, that it seems impossible to give any satisfactory account of it within the compass of two little books of 140 and 130 pages; such a sketch can only be a bare outline, and to make even this satisfactory in its own way the author requires to have a grasp of his subject such as few zoologists can boast. Prof. Macalister has unfortunately attempted to popularise his sketch more or less, and in consequence has in several places conveyed erroneous or imperfect impressions to his readers. Prof. Macalister's volumes are freely illustrated, but the illustrations, many of which are old acquaintances, are certainly not so good as those of the other volumes just noticed.

We may perhaps include under this same heading a series of books pro-

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* "The London Science Class Books." Edited by G. Carey Foster and Philip Magnus. Hydrostatics and Pneumatics by Philip Magnus; Botany (2 vols.) by W. R. M'Nab; Invertebrata and Vertebrata (2 vols.) by A. Macalister. Small 8vo. London: Longmans, Green & Co., 1878.

duced by Mr. Thomas Twining* although these are intended more for the guidance and instruction of teachers than as treatises to be read by students. Mr. Twining, as is well known, has devoted much attention to the subject of education, and especially to the diffusion of elementary scientific knowledge among the working classes, with a view to which he got together on his premises at Twickenham an extensive museum of objects and apparatus for the illustration of "the science of daily life." Unfortunately just when this interesting collection was ready to be transferred to a central position in London a fire broke out in the building containing it, and the results of fifteen years' labour were destroyed. In connection with this economic museum while it was still in existence, Mr. Twining prepared a series of lectures, which he has published, preceded by an introduction describing the mode in which he thinks his lectures may be best employed, and giving certain other details in connection with the course of instruction laid down in them, and the best mode of conducting examinations to test the advantage gained by the hearers. The lectures and introduction are published in six parts, which may be obtained separately, each part containing two lectures. Of these three are on Mechanical Physics, one on Chemical Physics, two on Chemistry (Organic and Inorganic), one on the Mineral and Vegetable Kingdoms, one on the Animal Kingdom, and two on Human Physiology, and the series is arranged so as to lead up to the practical application of the last to the purposes of daily life. The idea is an admirable one and exceedingly well worked out, the lectures being at once simple and good, so that they may either be read *in extenso* as the author proposes, or employed to furnish the skeletons of discourses to be filled up in the lecturer's own style. The indications of diagrams and illustrative experiments, of the apparatus for the performance of the latter, and of books of reference for the use of those who wish to supplement the information here given by reading, render this an exceedingly complete and valuable publication, which we can recommend with perfect sincerity to the notice of all school teachers and amateur lecturers on the subjects which it embraces, and also as a reading-book for beginners. We are glad to learn that Mr. Twining's labours in the cause of scientific education have met with due appreciation in Paris, the present series of books having received the honour of a silver medal from the Jury of the recent International Exhibition.

THE GEOLOGICAL RECORD.†

WE have much pleasure in announcing the publication of the third volume of the "Geological Record," which contains an analysis of the geological literature of 1876. The general plan of the work has undergone no

* "Science made Easy; a Series of Familiar Lectures on the Elements of Scientific Knowledge most required in Daily Life. Prepared in connection with the Twickenham Economic Museum, for delivery at popular institutions, for the use of schools and for home study." By Thomas Twining. 4to. London: Hardwicke & Bogue, 1878.

† The "Geological Record for 1876." An account of works on Geology, Mineralogy, and Palæontology, published during the year, with Supplements for 1874 and 1875. Edited by W. Whitaker, B.A. 8vo. London: Taylor and Francis, 1878.

change, but one or two minor modifications have been made in it which in no way affect the usefulness of the "Record" as a work of reference. Appended to the report for 1876, are two supplements containing references omitted in the previous volumes for 1874 and 1875; these of course add to the completeness of the book, but for convenience of reference we cannot help thinking that it would be better to work these supplementary articles into their places in the body of the work, simply indicating by dates in brackets that they belong to previous years. Most of those who consult the "Record" do so to inform themselves as to the literature of some subject in which they are interested, and care little for the historical fact that a certain amount of work was done in a certain year; and it must be borne in mind that, as the number of these supplements increases, there will be a correspondingly increasing difficulty in consulting the volumes for information upon any particular department of geological investigation. We throw out this hint for the consideration of the editor, fully recognising the importance of the service done by him and his coadjutors to their brother geologists, and hoping most cordially that he may realise that seemingly Utopian vision of seeing a copy of his little book, as he modestly calls it, in the hands of every geologist. Considering the value of the work and the low price at which it is brought out, it is a matter of wonder that every year the editor should have to sing the same song with its burthen of "more subscribers wanted."

SCIENTIFIC SUMMARY.

ANTHROPOLOGY.

The Wisdom-Teeth and the Evolution of Man.—The results of Prof. Mantegazza's researches on the posterior molar teeth in man, which are briefly referred to by Mr. Darwin in his "Descent of Man," have appeared in a memoir entitled "Il terzo molare nelle razze umani," published in the last number of the "Archivio per l'Anthropologia." These researches were undertaken to test the soundness of the view put forward by Mr. Darwin that "the posterior molar or wisdom-teeth were tending to become rudimentary in the more civilised races of man," and the rich craniological collection in the national museum at Florence, which has been carefully examined by Prof. Mantegazza, must have afforded ample materials on which to found an opinion. After rejecting those skulls which were too old, too young, or too imperfect to permit of useful investigation, no less than 1,249 skulls passed through Prof. Mantegazza's hands, of which 844 were those of modern highly-civilised races, 277 those of modern inferior races, and the remaining 128 belonged to Romans, Etruscans, Phœnicians, and other nations of antiquity. From the investigation of these skulls he finds that the wisdom-teeth are more frequently wanting in the superior than in the inferior races of man, the proportion being 42·42 per cent. in the higher against 19·86 per cent. in the lower types, which result agrees entirely with Mr. Darwin's view. Prof. Mantegazza, however, finds that atrophy of the third molar occurs less frequently in the higher than in the lower races, the proportion in this case being 10·90 per cent. in the higher to 20·58 (or very little short of double) in the lower types. While in the lower races the abnormal and normal cases are virtually equal (the figures being 50·44 in the latter and 49·46 in the former), with the higher races the fact is found to be very different, there being no less than 62·91 per cent. of abnormal to 37·09 per cent. of normal teeth. The crania of ancient types appear to stand intermediate between the higher and lower races of modern times, exhibiting 27·34 per cent. of skulls in which third molars are wanting, and 16·41 per cent. in which they are atrophied. With respect to the number of fangs possessed by wisdom-teeth, Prof. Mantegazza's investigations show that these teeth have three roots in 51·35 per cent. of the skulls of modern high races, in 45·20 per cent. of modern low races, and in 46·43 per cent. of ancient types. While wisdom-teeth with four and with two fangs were found to be more common in the modern high races than in any others,

teeth having but a single root are of more frequent occurrence in the skulls of lower types, and in only one case was a wisdom-tooth with five fangs observed, in a modern skull of high type. As an almost invariable rule the third molar of the lower jaw was found to possess two roots, though occasionally in the higher types four roots were observed. The result of Prof. Mantegazza's investigations strongly corroborates the view put forward by Mr. Darwin, and leads the Professor to believe that at some future period the third molar may permanently disappear from the human jaw.

The Colour of Human Hair.—In a paper published in the August number of the "Journal of the Anthropological Institute," Mr. H. C. Sorby has described the results of some investigations in which he endeavoured to separate the pigments contained in the hair, and to subject them to a chemical and spectroscopical examination. His researches lead him to the conclusion that hair is a colourless horny substance, the tint in different specimens being due to the presence of three or perhaps four distinct pigmentary bodies. These pigments being protected by the horny matter of the hair, are unaffected by water, alcohol, and other common solvents, and sulphuric acid more or less dilute appeared to be the best medium for separating the colouring principles, though, by its agency, it was possible that decomposition might be effected, and products be thus formed which were not originally present in the hair. This small difficulty was, however, one with which so experienced an analyst as Mr. Sorby would have no trouble in grappling. From the different kinds of human hair which he examined he obtained a reddish, a yellow, and a black pigment, the first of which, being an unstable body, may possibly pass into yellow by a process of oxidation. In bright red hair the red constituent was found to be present unaccompanied by other pigments; while dark red hair contains a certain proportion of the black colouring matter. Golden hair contains less red and more yellow colouring matter, while in hair of a sandy tint a proportion of the red and black principles are associated with a large quantity of the yellow pigment, and in dark brown hair the black principle increases, and the yellow and red are greatly reduced in quantity; until in black hair the two latter substances almost disappear, being replaced by the black pigment. In some cases, however, as in that of the black hair of a negro, the black colouring matter was accompanied by a quantity of the red pigment, equal in amount to that found in the bright red hair of Europeans, which leads to the conclusion that had the supply of black pigment failed from any cause, this negro's hair instead of being white would have been of as bright a red as the hair of the most typical Celt.

Osteology of the Achinese.—An Achinese skeleton, doubtless the first which has ever reached Italy, has lately been presented to the Anthropological Museum at Florence, and forms the subject of "Studi Anthropologici intorno ad uno Scheletro Accinese," published by Dr. Ricciardi in the "Archivio per l'Anthropologia." The people inhabiting the interior of Achin, in the northern part of the Island of Sumatra, differ in many important respects from the neighbouring Battas or Battaks, and have sometimes been regarded as a "cross" between the Battak and Malay types. The skull examined by Dr. Ricciardi agrees, however, most closely with that of a Battak, and has a cephalic index of 76·24, so that it belongs to the orthocephalic group of

Professor Huxley or to the subdolichocephalic group of Broca. It is to be observed that the only skulls coming from Sumatra with which Dr. Ricciardi was able to compare his specimen were seven described by Dr. Barnard Davies in his "Thesaurus," and amongst these there is not a single example of an Achinese skull. On comparison with the skulls of Javanese, Dyak, Papuan, Malay, and Chinese the measurements of the Achinese cranium were found closely to agree with the Dyak, but to differ in many important respects from the Malay; while there is a certain amount of agreement between it and the Chinese skull, though it differs materially in the character of the orbits, facial bones, and upper jaw. Interesting as the description of this skeleton must prove to anthropologists, it must be remembered that from a single specimen it is unsafe or rather impossible to draw any sound conclusions, as the peculiarities observed may be due, not to specific variations but to an abnormal development of the individual.

ASTRONOMY.

Photographs of the Total Solar Eclipse of July last.—Mr. Ranyard thus presents the results of photographic work during this eclipse:—"The photographs taken by Dr. Brackett during the recent eclipse with a six-inch telescope of rather more than seven feet focal length, seemed, as far as I could judge, to be equally dense with the photographs of similar exposure of Lord Lindsay's and Colonel Tennant's series, taken in India, 1871. I speak with some caution, as I have not had an opportunity of comparing the negatives side by side; but the density of the Indian negatives is very well impressed on my mind, as I spent more than a year in making out and cataloguing the details which are visible upon them. It must be borne in mind, that during the Indian eclipse, the sun, as seen from the two photographic stations, was at a lower altitude than as seen at Denver, Dr. Brackett's station; but while the angular aperture of Dr. Brackett's instrument was less than one in fourteen, Lord Lindsay's and Colonel Tennant's cameras were of four inches' aperture, and about thirty inches focus, or one in seven and a half—that is, in the two Indian cameras, which were of similar construction, the pencil of light falling on an element of the plate, was nearly four times as intense as the pencil falling on a similar element in Dr. Brackett's telescope camera. We have no data, of course, for comparing the diactinism of the Indian and Colorado atmospheres. But we may, I think, feel justified in asserting that as far as the evidence derived from the photographs of 1870, 1871, and 1876 goes, the corona does not wax and wane with sun-spots. In fact, the corona with by far the greatest equatorial extension is found at a period when there are hardly any spots upon the sun's disc, and it should also be remembered that the difference between the coronas of 1870 and 1871 does not at all correspond with the development of sun-spots at the two periods."

Polarisation of the Corona.—Mr. Schuster notes that the polarisation of the corona seems at first to increase with distance from the sun, and then to decrease rapidly. Doubtless, the explanation suggested by Mr. Ranyard is the correct one. Near the sun the matter of the corona is in-

candescent, and the light from it is in large part unpolarised; on the other hand, the light from the outer part of the corona is mixed up with light from our own atmosphere, drowning the polarisation of the outer corona.

Meteoric Theory of the Corona.—Mr. Penrose infers from the observed aspect of the coronal streamers that they are due to meteoric systems. "I am far from arguing," he says, "that this theory answers for the whole of the corona, and I much doubt whether it will explain the almost equal and radial lines which proceeded from the neighbourhood of the sun's north pole, and which appeared to me the most beautiful part of the whole. There was also something analogous near the sun's south pole, but not so clearly radial. The pointed ends of the 'wind vane' (a name suggested by the shape of two opposite sets of streamers) seem to suggest the explanation of an elliptic orbit of considerable major axis and great eccentricity. The wedge-like point proceeding from the north pole of the sun would agree with a similar figure, whilst some of the others can be explained by orbits of meteors of less extent. It is obviously not requisite that the sun's centre should be the focus of the apparent orbit, as it would be modified from the real figure by perspective."

Foreign Observations of Meteor Showers.—From observations recorded by Heis, Weiss, Schiaparelli, Zezioli, and Konkoly, Mr. Denning has drawn up a useful list of 79 meteor showers in the Notices of the Astronomical Society for November. We observe that he still fails to recognise the validity of the objections raised by Captain Tupman and others, against his idea that meteors belonging to the same system can appear to radiate from the same point in the sidereal heavens for several successive weeks. He seems to suppose that planetary perturbations acting on attenuated meteor streams might diffuse them, so that a considerable time would be required for the earth's passage through them, while the radiant points remained sensibly unaltered. He says it "has yet to be ascertained" whether this is possible. But nothing can be more certain than that this is utterly impossible. He appears also to suppose that the results of observation are questioned by Captain Tupman and the other objectors. "Observers will state the legitimate result of their labours," he says, "apart from theoretical considerations, however incompatible they may at first appear." It was to his interpretation of his results that exception was taken, not to the results themselves. If observers have obtained clear evidence showing that at different times between the middle of October (to take one case) and the middle of December, meteors radiate from the same point of the stellar heavens, their statement must be accepted. But when they proceed to assert that, therefore, the meteors so seen belong to one system, the mathematician perceives that the inference is entirely erroneous. It is absolutely certain, if the results of observation are admitted, that the meteors belong to different systems. The reasoning runs simply thus:—We know that the members of a meteor system are bodies travelling around the sun in orbits passing near the earth's; and that their "radiant" at any given date is a point depending on the combination of their motion with the motion of our earth, the direction as well as the velocity of each motion being involved. If, then, it were possible for a meteor system to be so widespread that the earth required eight or nine weeks to pass through it, and even if the directions of the meteors at all parts of her arc of

passage were roughly parallel, yet, as the direction of the earth would change through about sixty degrees, the position of the radiant would change markedly during those eight or nine weeks. But observation, it seems, indicates the same "radiant." Hence it is certain that the meteors belong to different systems. We could, in fact, only accept Mr. Denning's inference if we rejected his observational results.

Observations of Jupiter and his Satellites.—Mr. Todd presents a very valuable and interesting series of observations of Jupiter and his satellites, with the Adelaide equatorial, in the Monthly Notices for November. "The visibility of the satellites through the edge of the planet has been carefully looked for," he says, "and on two occasions I felt quite certain I saw the satellite at occultation within the disc—namely, on June 19 at occultation-disappearance of Satellite II., and on July 2 at disappearance of Satellite I. Mr. Ringwood also saw the same phenomenon at the disappearance of Satellite II. on August 29. I thought I could see Satellite III. through the limb at reappearance on June 9, and Satellite II. at disappearance on July 21, but could not be certain. In every other case the occultation was perfect at the limb. On June 19, Satellite II. was visible through the white belt south of equator, and on July 2 Satellite I. was seen for the space of one minute through the southern dark belt. It would be interesting to know whether this has been seen by other observers. The definition on each occasion was very good, or I should think I might be deceived." The observation on July 2 is a very singular one. Mr. Todd's notes say that "the satellite was distinctly seen through the edge of the planet *for the space of its full diameter*."

Tempel's Short Period Comet.—This comet, as observed at the Oxford University Observatory from July 27 to August 1, resembled a faint round nebula of about 1′ in diameter. The condensation was very slight.

Encke's Comet.—This comet was observed by Mr. Tebbutt, at Windsor, New South Wales, from August 3 to August 13. On August 3 it presented the appearance of a small round nebula, gradually condensed towards the centre, and was within a few minutes of arc of the position assigned to it in the ephemeris.

Intra-Mercurial Planets.—From a comparison of his own and Professor Watson's observations of stars near the sun during the last total eclipse, Professor Swift arrives at the conclusion that four intra-Mercurial planets were seen on that occasion—two by himself and two by Watson. He considers that both the stars he himself saw were planets, since, if one of them had been, as he before supposed, the star Theta Cancri, Watson could not have failed to see the other. For a similar reason neither of them can have been the object which Watson saw near Theta Cancri. The other object, which Watson at first mistook for Zeta Cancri, is now regarded by him very confidently as a planet. Accordingly, it would follow that four intra-Mercurial planets were seen by these two observers, and that all were so situated as to present appreciably round discs. Other observers, who with equal or better means sought specially for such planets, would seem to have been singularly unfortunate.

The Annular Eclipse of January 22, 1879.—Mr. Hind states that this eclipse, the first of the annular eclipses of 1879, and a return of that of January 10, 1861, which was central in Australia, commences in Uruguay,

whence the belt of annular phase traverses the South Atlantic, passing over Tristan d'Acunha, the few inhabitants of which islands may probably be startled by seeing the sun transformed into a narrow luminous ring, while he is high in their heavens. The central line crosses the African continent in the direction of Pemba Island, north of Zanzibar, where the annularity will continue nearly three minutes; the middle of the eclipse occurring at 4h. 6m. P.M., local mean time.

Comets of Short Period.—Prof. Schuler states that Brorsen's comet will arrive at perihelion on March 30, 1879. It is probable that the comet will be first observed in the southern hemisphere. About six weeks later Tempel's comet 1867(II.), which was reobserved in 1873 (after undergoing great perturbation from the planet Jupiter), will be due at perihelion. "The elements deduced from the observations of 1873 alone," says Mr. Hind, "would assign, without taking account of perturbation, April 26, for its perihelion passage; but according to an orbit just published by M. Raoul Gautier, of Geneva, which he says may be considered the most probable one till the observations to be expected next year afford additional means of determining the mean motion, the comet would not be in perihelion till May 8; in which case its apparent track in the heavens will differ little from that which it pursued in 1873, when it arrived at its least distance from the sun on May 9. It is pretty sure to be always a faint object except for the larger telescopes; and considering the uncertainty which still appears to exist regarding the mean motion at its last appearance, a close search may be necessary for its rediscovery. M. Gautier is calculating the effect of Jupiter's attraction during the actual revolution, with the intention of publishing an ephemeris in due time: this effect, however, must be small, as the comet has not been nearer to the planet than 1·5 (earth's distance from the sun being 1) "during the interval."

Sun-spots and Commercial Panics.—Among the many absurdities which the advocates of national solar observatories have invented, none is more absurd in itself, or more flatly contradicted by evidence, than the singular theory that commercial panics usually occur near the epochs of sun-spot minima. We know the dates of sun-spot maxima and minima since 1700, in every case within a year or so. We have also the list of commercial panics ingeniously prepared by Prof. Stanley Jevons to accord with the doctrine that the sun-spot period has an average value of 10·46 years; and instead of the asserted agreement between sun-spot minima and panics, we find more than half of Jevons's panics occurring nearer to sun-spot maxima than minima. Two of the most remarkable panics occurred almost exactly at the time of maximum solar maculation. The advocates of expensive new observatories seem to imagine that no one will be at the pains to analyse the evidence they offer. But, though the theory of special sun-spot influences is no doubt too absurd to be seriously dealt with, the arguments offered, with seeming seriousness, in its favour, are not likely to escape criticism altogether. No one would seriously try to prove that the panic of 1866 did not occur for want of sun-spots that year; but when the panic of 1815 is associated with a sunspot minimum, science may, without absurdity, just throw in the remark that 1815 was a year of maximum not of minimum sun-spottedness.

Planetary Phenomena, &c.—Uranus will be in opposition to the sun on February 21 at 4 A.M. Mercury will be at greatest elongation west on January 16, east on March 29.

BOTANY.

Sensitive Organs in the flowers of Asclepiads.—Dr. J. Gibbons Hunt communicated to the Academy of Natural Sciences of Philadelphia, on the 27th of August last, some observations on the flower of *Asclepias asterias*, which he had been informed by Mr. Isaac Buck was probably a fly-catcher. The odour of this flower, which is exceedingly disagreeable to human olfactory organs, appears to be very attractive to flies, many of which were watched by Dr. Hunt "eagerly applying their tongues all over the petals and essential organs, apparently eating with almost intoxicated relish the attractive excretion covering those parts." They continued to indulge freely in this banquet until they happened to touch one of five black spots placed alternately with the stamens, when the fly was immediately seized and held fast by his proboscis. In the struggle that ensued the fly, if small and weak, would be held fast in the trap; if large and strong he would make his escape, but burdened with the trap and with a pair of pollen-masses attached to the latter. The adhesion of the fly's proboscis to the black spots is not due to any sticky fluid; but it is caught by an organic structure, the action precisely resembling that of an ordinary rat-trap. The sensitive black discs may be set in action by contact with a bristle.

Analogous arrangements occur in other genera of the *Asclepiadeæ*, and on the same occasion Mr. Edward Potts gave an account of his observations on two species of *Asclepias* (*A. incarnata* and *curassavica*) in which similar phenomena take place. The sensitive organs are placed immediately below the anther-sacs in shallow depressions upon the perpendicular ridges of the stigma. Two pollen-masses are attached to each clasping organ by long bent filaments, and these are withdrawn from the anthers when the organ has clasped the leg of an insect, a bristle, or a small camel-hair pencil. As evidence in support of this arrangement being destined to cause cross-fertilization, Mr. Potts mentioned his having found upon flowers of *Asclepias curassavica* foreign sensitive organs with their attached pollen-masses, which must have been brought there by some external agency. In each case one mass of the introduced pair was inserted under the edge of the anther of the flower, so as to come close against the sloping lower surface of the stigma; the flowers thus intruded upon persisted longer than others of the same group, and on dissection it was found that each of the inserted pollen-masses had sent out a profusion of pollen-tubes towards the junction of the stigma and the style.

A Catalogue of British Plants.—We understand that the Rev. George Henslow, F.L.S., is about to print a catalogue of British plants arranged according to "Hooker's Students' Flora." Anyone wishing for copies is requested to communicate with him, at No. 6 Titchfield Terrace, Regent's Park, N.W.

The "Pro-embryo" of Chara.—In the "Journal of Botany" for July last Mr. A. W. Bennett, writing on the systematic position of the *Characeæ*, proposes to unite that order with the *Muscineæ*; later Prof. Caruel assigned it a position between the vascular cryptogams and the phanerogams; and in a still later paper Mr. Sydney Vines looks upon it as an independent group, intermediate between the *Carposporeæ* and the *Muscineæ*. Both Mr.

Vines and Mr. Bennett agree that it is incorrect to place the *Characeæ* among the *Carposporeæ*, since they have stronger affinities with the mosses, with which the latter proposes to unite them. In this view, however, Mr. Vines does not concur. He holds "that a well-marked alternation of generations occurs in the life-history of the *Chara*, and that the *Chara*-plant with its reproductive organs is the oophore, the sporophore being represented by the embryo—*i.e.*, the product of the development of the central cell of the archegonium. In order to indicate the fact that no spores are ever produced, so far as is at present known, by the sporophore of *Chara*, we may speak of this plant as being 'aposporous,' using a word which is symmetrical with the term 'apogamous,' applied by De Bary to those ferns in whose life-history no process of sexual reproduction occurs."

On the Kind of Light required by Growing Plants.—In the *Comptes Rendus* of November last M. Paul Bert gives the results of his experiments on the action of coloured light on vegetable life. He found that, while plants covered with green glass shades stopped growing and quickly died, those covered by panes of red glass continued to live and grow, though with diminished vigour. On submitting the coloured panes of glass to spectroscopic analysis with an illumination equal to diffused sunlight, he found that the red glass intercepted the yellow and all the more refrangible part of the spectrum, only the orange and red rays passing through, while the green glass permitted all but the least refrangible three-fourths of the red rays to traverse it. Hence it appears that the light essential to the continuance of plant life must be included in that portion of the red which is absorbed by the green pane. In order to further define its limits M. Bert compared the absorbent effect of the green glass with that of a dilute solution of chlorophyll, which was found to stop only a small part of the red rays, namely those situated between B and C. M. Bert then constructed a case with double walls of colourless glass, the space between the walls being filled with the chlorophyll solution, and it was found that plants kept in this case, though freely exposed to light, not only ceased to grow, but died as rapidly as those put under green glass shades. Thus the exact nature of the light rays indispensable for the support of vegetable life was determined, and it would appear (though proof is still wanting) that the regions of the spectrum capable of being utilised by plants are precisely defined by the various absorption-bands of chlorophyll.

CHEMISTRY.

The Crystallisation of Silicic Acid in the Dry Way.—In 1868 Vom Rath found on a specimen of trachyte a variety of silicic acid which differed both in form and density from quartz; it was shown, in fact, that silicic acid, like sulphur, arsenious acid and antimonious acid can crystallise in two distinct forms. Hautefeuille now finds that this compound can be crystallised artificially in the dry way in these two different forms. Rose, who was the first to prepare the acid in the crystallised condition, obtained it, when a salt of phosphoric acid was employed in the form of tridymite. If amorphous silicic acid and tungstate of soda be retained for a long time at the fusing

point of silver, and the tungstate be extracted from the fused product by water, the insoluble portion has the appearance of a crystallised sand, and has within a few milligrammes the weight of the silica employed; that it is converted into tridymite is proved by the form and optical characters of the crystals. By protracted heating, larger crystals are formed. They have a specific gravity of 2·30, that of the natural crystals which Vom Rath examined, and which contained about 2 per cent. of metallic oxides, being 2·32, 2·31, and 2·29. If a heat higher than 1,000° be applied the crystalline plates dissolve in the tungstate, and a silicate is formed which floats in the melted salt; while at temperatures less high, at 900° or lower, tridymite crystals separate. It is evident that the alkali of the tungstate attacks the silica and forms with it an alkaline silicate, tungstic acid being set free; as the temperature falls it again combines with the alkali, and the silicic acid is liberated in the crystalline form. The reaction appears to take place at lower temperatures than in the case where a phosphate is used. If the fused mass already referred to be retained at a lower temperature—nearer, in fact, to its melting-point—at about 700°, transparent elongated bodies are formed; if the heating be continued for several hours, double pyramids of quartz are noticed which become strongly coloured when viewed between Nicol's prisms. The crystallisation in this case was found to proceed slowly, the action being more rapid when the temperature rose and fell frequently between 800° and 950°. Each time the mass cooled tridymite was formed; as soon, however, as the temperature fell below 850° quartz crystals made their appearance. In one instance, where the heating was prolonged for two months, about equal quantities of silicic acid had crystallised as quartz and as tridymite. The specific gravity of the mixed crystals was 2·46, a number intermediate between those representing the density of tridymite (2·30) and of quartz (2·65). In one instance, the greater part of the tridymite was mechanically separated, and here the number rose to 2·61. Analysis showed the crystals to contain 0·003 of soda and a mere trace of tungstic acid.—*Comptes Rendus*, 1878, vol. lxxxvi. pp. 1133 and 1194.

Philippium and Décipium.—Delafontaine announces the discovery of two metals to which he has given the above names. The former occurs in samarskite; its oxide is yellow, like terbia, and has a molecular weight intermediate between those of yttria and terbia. He has satisfied himself that it is not a mixture of those two bodies, and gives the new metal the name Philippium in honour of M. Philippe Plantamour, of Geneva. The formiate of philippia is less soluble than the corresponding salt of yttria, and its oxalate is more readily soluble in nitric acid than the corresponding salt of terbia. A concentrated solution of a salt of philippium shows a fine absorption band in the indigo ($\lambda = 450$ nearly), two in the green, a faint one in the blue, and one in the red. (*Comptes Rendus*, 1878, vol. lxxxvii. p. 559.) A fortnight after the publication of this note, Delafontaine announced (*Ibid.* p. 632), the discovery of a second metal in the samarskite of N. Carolina, and this he has named Décipium. It forms an oxide, the equivalent of which is close upon 122 for the formula DpO (or $Dp_2O_3 = 366$). The acetate is less soluble than that of didymium, and more so than that of terbium; the décipio-potassium sulphate is only slightly soluble in a concentrated solution of potassium sulphate, but easily soluble in water. The absorption

spectrum of the nitrate exhibits three bands at least in the indigo and blue. The most refrangible band is a little smaller than that of philippium, or the *m* of didymium. It occupies a space between Fraunhofer's lines G and H, being rather nearer to G, at a point where didymium and terbium show no lines; then there are two bands in the violet which appear to be H and H′. References to the wave-lengths of these and other bands will be found in the author's paper. The North Carolina samarskite has now been shown to contain the following earths:—

Name.	Equivalent.
Yttria	YO = 74·5
Erbia	ErO = 130
Terbia	TbO = 114–115
Philippia	PpO = 90 (about)
Décipia	DpO = 122 (about)
Thorina	ThO_2 = 267·5

as well as the oxides of didymium and cerium. Delafontaine traces the following interesting relation between the equivalents of some metals of this group:—

Yttrium	58	
Philippium	74	= 58 + 2 × 8
Terbium	98	= 58 + 5 × 8
Décipium	106 (?)	= 58 + 6 × 8
Erbium	114	= 58 + 7 × 8

Mosandrum.—According to J. L. Smith, a new metallic element, to which he has given the above name, occurs in some of the native columbates. He refers to it in a paper published July last in the "Comptes Rendus" (1878, lxxxvi., 148) on the analysis of these minerals. He directs attention to the action of concentrated hydrofluoric acid on the samarskite and euxenite of West Carolina, which is as rapid and energetic as that of hydrochloric acid on calc-spar. By the application of the heat of the water-bath the powdered mineral can be completely broken up in a few minutes. He finds that the earths of the yttria group present in these minerals consist of one-third erbia and two-thirds yttria. The group contains no cerium, but nearly 10 per cent. of thorina, a small quantity of didymium oxide, and 3 per cent. of an earth which he believes to be new to science. He makes the atomic weight of the new earth to be 109 (when O = 16), those of oxide of cerium and lanthanum being 110, and of oxide of didymium 112, according to Marignac. The new oxide is stated to differ from the earths of the yttrium group as regards its reaction with potassium sulphate; from cerium oxide by its being soluble in very dilute nitric acid, or in an alkaline solution through which chlorine has been conveyed; from didymium oxide by its colour as well as in other features, especially the absence of the characteristic absorption bands; and from lanthanum oxide by its colour, the crystalline form of the salts, &c. It appears that the discovery was communicated to the Academy of Sciences more than a year ago, and publicly announced at Philadelphia in May last year. Marignac, who can speak with authority on the question, does not find in any of the reactions quoted by the discoverer sufficient reasons for distinguishing the earth in question from terbia. He finds that the sulphate

of mosandrum can be redissolved in an excess of potassium sulphate. It is less soluble than yttria and erbia are; and this is, in fact, a characteristic of terbia, as pointed out long since by Delafontaine.

A New Organic Base in Animal Organisms.—During the last twenty-five years many observers have described some peculiar crystals which are to be met with in certain organs of the animal body as well as in such fluids as blood, saliva, pus, &c., both in health and disease. Charcot, in 1853, was the first to draw attention to them, and by many writers they are spoken of as "Charcot's crystals." Some have supposed them to be tyrosine, others phosphate of lime, and others again a compound allied to albumen. Schreiner has now shown ("Annalen der Chemie," 1878, c. xciv., 68) that they are the phosphate of a new base. The pure substance has marked alkaline properties, and forms little groups of crystals resembling wavellite. It dissolves in absolute alcohol, and is only slightly soluble in ether; when heated with a solution of potash or soda it evolves ammonia, and gives a flocculent white precipitate with zinc chloride. The hydrochlorate forms a double salt with platinum chloride, which separates in large prismatic crystals; the double salt of gold is also a crystallised body. An analysis of the hydrochlorate of the base gave numbers which point to C_2H_5N,HCl as the formula of this salt. A second paper by the author will shortly appear.

Iron Phosphide.—Percy observed that iron will not take up more than 8·4 per cent. of phosphorus when those substances are heated together. J. E. Stead, in a paper recently read before the Cleveland Institution of Engineers ("The Chemical News," 1878, xxxviii., 14), states that he has succeeded in obtaining combinations of phosphorus, varying between 6 and 27 per cent. The point of fusion of the compound is lowered with each addition of the metalloid until a substance containing from 10 to 12 per cent. of phosphorus is produced, after which each addition makes the compound less and less fusible. Iron phosphide containing 11 per cent. of phosphorus is quite fluid at a bright red heat; the compound with 25 per cent. is infusible at that temperature. If a partially-fused pig of Cleveland iron be broken across, the fractured surface "presents throughout glistening, apparently fluid, portions, thoroughly interspersed with particles of metal which have not become fluid." Stead poured one cwt. of Cleveland iron into a mould and, when on cooling it had become viscous, he applied great pressure to it by means of a hydraulic ram. Below are given the composition of the iron itself (I) and that of the last portions of fluid metal expressed from it (II):—

	I.	II.
Iron	93·125	90·122
Carbon	3·000	1·750
Manganese	0·355	0·288
Silicium	1·630	0·790
Sulphur	0·120	0·060
Phosphorus	1·530	6·840
Titanium	0·240	0·150
	100·000	100·000

The latter may be regarded as a mixture of iron phosphide, and unaltered pig; and a calculation of the amount of the last-named constituent, based on

the quantity of silicium present, shows the mixture to consist of 48·5 per cent. of pig iron and 51·5 per cent. of a phosphide composed of

Iron	88·05
Phosphorus	11·95
	100·00

A second similar experiment, made six months later, gave numbers which point to the fusible phosphide having the composition

Iron	88·26
Phosphorus	11·74
	100·00

It appears, therefore, to possess a definite composition corresponding to the formula Fe_4P.

Nodules from the Deep Sea.—Gümbel publishes an interesting and very complete analysis of some of these nodules. Between Japan and the Sandwich Islands the sea-bed is covered with red mud, fragments of pumice, and the so-called "Manganese nodules." Those which he examined had been dredged up by the "Challenger" from a depth of 2,740 fathoms. They are rounded or flattened, have a dull brown colour, and enclose particles of pumice, teeth of fish, &c. The nodules scale off in layers, and a careful inspection of cross sections convinced the author that the structure is due to mechanical action, and not to the agency of any organism. The pumice is trachytic. He is of opinion that the material constituting the nodules has been derived from submarine sources. A very complete analysis of a fragment of one of these interesting bodies was made, and it was found to have the following composition:

Iron sesquioxide	27·460
Manganese peroxide	23·600
Alumina	10·210
Lime	0·920
Magnesia	0·181
Soda	2·358
Potash	0·396
Baryta	0·069
Silicic acid	16·030
Titanic acid	0·660
Sulphuric acid	0·484
Carbonic acid	0·047
Phosphoric acid	0·023
Chlorine	0·941
Copper oxide	0·023
Nickel (cobalt) oxide . . .	0·012
Water	17·819
	101·233

The low proportion of carbonic acid present in these nodules is very remarkable (*Sitzungs-Ber. baeyer. Akad. Wiss.* 1878, 2.)

GEOLOGY AND PALÆONTOLOGY.

Crabs in the Coal-measures.—Hitherto the Brachyuran, or short-tailed Crustacea, have been regarded as of comparatively recent origin. Most of the known fossil forms have been obtained from Tertiary beds; and of the few Secondary species the most ancient appears to be one from the Forest Marble of Malmesbury, Wiltshire, described by Dr. H. Woodward under the name of *Palæinachus longipes.* A specimen just described by the same distinguished palæontologist carries the group of short-tailed Decapods or crabs much further back in time; it is the tail or abdomen of an animal of this group from the coal-shale near Mons, in Belgium. This abdomen, which is preserved upon a slab of shale bearing impressions of the ferns *Neuropteris heterophylla* and *Alethopteris lonchitidis,* is about half an inch long, and nearly perfect. It consists of seven segments more or less completely anchylosed together as in the Leucosiidæ; its general form is oval, truncated at the base where it was attached to the cephalothorax. The central part or axis of the abdomen consists of a large trapeziform basal segment, having a large tubercle on each side of the middle line, and three small impressed points near the middle of the hinder margin, followed by five smaller, transversely oblong segments, gradually diminishing towards the apex, and each marked with three points corresponding to those in the first segment. The seventh or last segment is again of large size, and widens in a fan-like form towards the extremity of the tail. The lateral portions of the tail, completing its general oval form, are ornamented with tubercles, a distinct row of which accompanies each line of division between the different segments, and runs out to the edge of the abdomen, where each divisional line terminates in a slight projection, giving the margin of every segment a gently concave form. For this crab Dr. Woodward proposes the name of *Brachypyge carbonis.* It furnishes the first clear evidence of the existence of true crabs during the coal-measure era, although Dr. Woodward states that he has received from Mr. M'Murtrie fragments apparently of Brachyura found in the Radstock coal-field, near Bristol, and at the Pendleton colliery, near Manchester.—*Geological Magazine,* October, 1878.

A New Order of Fossil Rhizopods.—Prof. P. Martin Duncan describes (Ann. Mag. Nat. Hist. October, 1878), some spheroidal bodies obtained in the Karakorum mountains, which he regards as indicating a new order of Rhizopods. The fossils are calcareous, and present no traces of having been attached during life; their surface presents rounded or wart-like elevations, and sometimes depressions resembling large pores; and they measure from one to three inches in diameter.

The surface consists of a close reticulation of minute tubes, of the openings of such tubes, and of interspaces between the tubes. Internally the fossils consist of tubes from $\frac{1}{300}$ to $\frac{1}{1000}$ inch in diameter in limited radial groups, which are separated by a reticulation of inosculating tubes, such as are seen on the surface. The radial groups of tubes form cones with the apex towards the centre, and the base usually forming one of the eminences on the surface of the fossil. The interradial tubes are derived from the radial ones, and the walls of all the tubes are composed of opaque, granular, irregular, semi-spiculate-looking, and very minute particles of carbonate of lime.

There are no diaphragms, intertubular structure, or cœnenchyma; the spaces between the tubes are filled, in the fossils, with calcite, which also occupies the tubes. The course of the radial tubes is sometimes straight; but usually they bend suddenly and repeatedly, and then pursue a straight course. They divide repeatedly.

Of these curious and exceedingly problematical fossils, which he says are not crinoids, corals, sponges, or Foraminifera, Prof. Duncan proposes to make a new order, Syringosphæridæ, and in it he distinguishes two genera:—*Syringosphæra* with eminences and pores on the surface, and *Stoliczkaria* without pores.

Silurian Land-plants.—In September, 1877, Count Saporta described a fern from the slaty schists of Angers under the name of *Eopteris Morierei.* He now (*Comptes Rendus*, 18 November, 1878) describes further evidence of the existence of ferns at the time of deposition of these rocks, referred to near the base of the Middle Silurian. His new material is the impression of the frond of a fern nearly 9 inches long, and about 3 inches in average width. It shows a slender rhachis bearing 7 pairs of leaflets, which are opposite or nearly opposite, of a rounded oval form, traversed by fine, divergent, flabellately dichotomous veins. These leaflets are sessile upon the rhachis, or nearly so. Beyond the seventh pair the apex of the frond is formed by a terminal leaflet, which appears to be round or reniform, folded upon itself, and perhaps composed of two portions partially soldered together. M. de Saporta names the species *Eopteris Criei*, after its discoverer, M. L. Crié.

Dwarf Crocodiles of Purbeck age.—Prof. Owen, in a paper read at the opening meeting of the Geological Society this session, described some diminutive crocodilian remains found in rocks of Purbeck age, which must have been contemporaneous with the well-known mammals of small size characteristic of these strata. In some slabs of "feather-bed" marl accompanying the Becklesian collection of Purbeck fossils in the British Museum, have been found in considerable abundance the remains of these dwarf crocodiles, to one of which Prof. Owen has given the name of *Theriosuchus pussillus.* This crocodile appears to have been only about eighteen inches in length. It had its scales connected by the "peg and groove" arrangement, as in *Goniopholis*, with which genus it also agrees in many of its cranial characteristics, while in dentition it approaches more nearly to the Triassic Theriodonts than any other crocodiles.

Lithology and the Classification of Crystalline Rocks.—Prof. Dana has just completed a memoir "on some points in Lithology," and the conclusions at which he arrives seem to be of such importance that we here reprint them. He says the principal points brought out in his paper are the following:—

1. The necessities of the science of Geology constitute the most prominent motive for distinguishing *kinds* of rocks; and they should determine to a large extent upon what characters distinctions should be based.

2. In determining the rocks to be grouped as one in *kind* under a common name, near identity in the chemical and mineral composition of the chief constituents is the main point to be considered; not near identity in their crystalline forms, for isomorphism presupposes diversity of composition.

3. Distinction of *kind* should be based on difference in chemical and

mineral constitution as regards the chief constituents. When such difference exists, rocks are different in *kind*, and need, for the purposes of geology, distinct names. If it does not exist, the distinction is only that of *variety*, unless (as in the case of trachyte and felsyte), the very wide extension of the rock under persistent characters makes a distinction of name important to geology.

4. It follows from the preceding that differences in texture: as coarse, or fine, or aphanitic; porphyritic, or non-porphyritic; stony throughout, or having unindividualised portions among the stony grains; and differences in microscopic inclusions; are no basis for a distinction of *kind* among rocks, but only of variety, and that *porphyritic structure* is of hardly more consequence than coarse or fine granular.

5. No marked change in the constituents of the earth's erupted material occurred after the close of the Cretaceous period, or just before the commencement of the Tertiary era; and, hence, no gronnd exists for the distinction of "older" and "younger" among eruptive rocks. The "younger" eruptive rocks are essentially like the "older" in chemical composition, and their chief mineral constituents; and they differ, when at all, only in texture and some other points of as little importance—qualities that distinguish merely varieties, and which have proceeded from greater prevalence in these later times of sub-aerial eruptions.

6. Since "plagioclase" is not the name of a mineral species—several minerals of widely different compositions being embraced under it—it is a confounding of differences and resemblances to speak of it as a constituent of a rock. And since it now includes, through the defining of the feldspar microcline, a large part of potash feldspar, which had been supposed to be orthoclase, it has become almost synonymous with the term feldspar. The "simplicity" its adoption has been supposed to give to lithological system would be greater if "feldspar" were substituted, and with its present range of constitution, the evil would be hardly less.

7. Rocks differing mineralogically, and not chemically, like related hornblendic and augitic rocks (the minerals hornblende and augite being dimorphous) are rightly made distinct rocks, since the difference has depended, to a large extent, on wide-reaching geological operations or conditions, and is, therefore, of great geological significance.

8. Since quartz is the most widely distributed and therefore the least distinctive of the minerals of rocks, it may rightly be regarded as of subordinate importance in the distinguishing of rocks, and hence not only such names as *dioryte* and *quartz-dioryte, trachyte,* and *quartz-trachyte,* &c., are acceptable, but also *syenyte* and *quartz-syenyte.*

9. Biotite being closely like muscovite in composition, and not less common than it in granites, gneisses and mica schists, and being, moreover, unlike the mineral hornblende in chemical constitution and formula, the rocks in which biotite is a chief constituent cannot rightly be put in the same group with hornblende rocks; or those in which hornblende is a chief constituent in a group of mica-bearing rocks. Consequently the name "mica-dioryte," for a rock containing no hornblende, and the name "hornblende-granite" for a rock containing no mica but hornblende instead, imply alike false relations.

The discussion suggests the following additional remark:

The incapabilities of the microscope and polariscope have favoured the use of the term "plagioclase," and have led some investigators to overlook or slight distinctions in chemical constitution. Lithology is to receive hereafter its greatest advances through chemical analysis; for chemistry alone can clear away the doubts the microscope leaves, and so give that completeness to the Science of Rocks which geology requires for right and comprehensive conclusions.

Moreover the researches made in the laboratory, to be of real geological value should be, if possible, supplemented by investigations in the field as to transitions among the rocks, and as to other kinds of relations. This field work has often been well done, but not so by all lithological investigators.

The principles presented lead to the following sub-divisions in an arrangement of crystalline rocks, exclusive of the Calcareous and Quartzose kinds. Since leucite is a potash-alumina silicate, like orthoclase and microcline (it affording twenty per cent. or more of potash), it is here referred to the same group with the potash feldspars, and nephelite, sodalite and the saussurites being eminently soda-bearing species, they are included with the soda-lime feldspars (anorthite to albite.) This reference for lithological purposes of these minerals is sustained by their resemblance to the feldspars in constituents, and also in the quantivalent ratios between the alkalies, alumina and silica, this ratio being in leucite 1 3 8, as in andesite, and in sodalite and nephelite 1 3 4, as in anorthite. The term *potash-feldspar*, as used in the headings below, is hence to be understood as covering orthoclase, microcline and leucite; and *soda-lime feldspar*, as including the triclinic feldspars from anorthite to albite, and also nephelite, sodalite and saussurites.

The arrangement is as follows:—In the first series, the rocks graduate into kinds which are all feldspar, and into others that are all mica, and yet the amount of potash present is approximately the same.

I. *The Mica and Potash Feldspar Series*: including Granite, Granulyte, Gneiss, Protogine, Mica schist, &c., Felsyte, Trachyte, &c., and the Leucite rock of Wyoming.

II. *The Mica and Soda-Lime Feldspar Series*: including Kersantite, Kinzigite, and the Nephelitic kinds, Miascyte, Ditroyt, Phonolyte, &c. (These nephelitic kinds belong almost as well in the preceding series.)

III. *The Hornblende and Potash-Feldspar Series*: including Syenyte (with Quartz-syenyte), Syenyte-gneiss, Hornblende schist, Amphibolyte, Unakyte (this last containing epidote in place of hornblende), and the Nephelitic species Zircon-Syenyte, Foyayte.

IV. *The Hornblende and Soda-Lime Feldspar Series*: including Dioryte (with Propylyte), Andesyte, Labradioryte (or Labrador-dioryte), etc., and the saussurite rock, Euphotide.

V. *The Pyroxene and Potash Feldspar Series*: including Amphigenyte.

VI. *The Pyroxene and Soda-Lime Feldspar Series*: including Augite, Andesyte, Noryte (Hypersthenyte and Gabbro in part), Hypersthenyte (containing true Hypersthene), Doleryte (comprising Basalt and Diabase), Nephelinyte, etc.

VII. *Pyroxene, Garnet, Epidote and Chrysolite Rocks, containing little or no Feldspar*: including Pyroxenyte, Lherzolyte, Garnetyte (Garnet rock), Eclogyte, Epidosyte, Chrysolyte or Dunyte (Chrysolite rock), &c.

VIII. *Hydrous Magnesian and Aluminous Rocks, containing little or no Feldspar*: including Chlorite schist, Talcose schist, Serpentine, Ophiolyte, Pyrophyllite schist, &c.—*Silliman's Journal*, December, 1878.

American Surveys.—In compliance with an order of the American Senate a Committee of the National Academy of Sciences has recently submitted to the President of the Senate its report upon the scientific surveys of the territories of the United States, and on the best methods of conducting all surveys of a scientific character under the War or Interior Department, and the surveys of the Land Office. The surveys particularly referred to in this report, are the Geographical surveys west of the one hundredth meridian under the War Department, the United States Geographical and Geological Surveys of the Territories, and of the Rocky Mountain region, under the Interior Department, the system of Land surveys under the supervision of the Land Office, and the coast and Geodetic surveys, one of the most important works now in progress in the interior. The objects of these surveys are: 1. An accurate geodetic survey; 2. A general and geographical reconnaissance; 3. Land parcelling surveys; and 4. The economic classification and valuation of the public domain. To these should be added the gradual completion of a general accurate topographical map of the United States, and all may be included under two distinct and separate heads, namely, Surveys of Mensuration, and Surveys of Geology and economic resources of the soil.

The report first considers the operations of the existing surveys of mensuration, which are now in progress under five different and independent organisations, and between which there is no co-ordination, the results of their work showing many contradictions, and moreover involving unnecessary expenditure. These five surveys are the coast and geodetic survey; the geographical surveys west of the one-hundredth meridian; the two topographical surveys under the Interior Department; and the Land Survey; but, as it is evident that both land parcelling and topographical surveys, to be sufficiently exact, must be placed upon a single rigid geodetic foundation, the report considers that these should be united into one comprehensive system, and recommends the coast and geodetic survey as best prepared to execute the entire mensuration required. It would therefore transfer that survey from the Treasury Department to the Department of the Interior, retaining its original field of operations, and giving it also the entire mensuration of the public domain under the name of the United States Coast and Interior Survey. This organisation would then embrace, in addition to its former work, a geodetic survey of the whole public domain, a topographical survey comprising detailed topographical work and rapid reconnaissance, and land-parcelling surveys.

As, however, this survey would not be called upon to notice the geological structure, natural resources and products of the territories surveyed the report recommends that an independent organisation should be established under the Department of the Interior, to be known as the United States Geological Survey, and to be charged only with the study of the geological structure and economic resources of the public domains.

With the inauguration of these two surveys the report recommends the

discontinuance of the present War Department surveys west of the one-hundredth meridian; of the geographical and geological surveys now in progress under the Department of the Interior; and of the land surveys under the Land Office.

These changes will bring within the Department of the Interior three distinct organisations—the Coast and Interior Survey; the United States Geological Survey; and the Land Office; and with this division the report considers that a perfect co-operation between the three branches should be secured, the work of each department being immediately available to the others. Each of the three organisations will make an annual report of its operations to the Secretary of the Interior, but besides this annual report the Coast and Interior Survey will publish its geodetic results, geographical, topographical, and cadastral maps, coast charts, &c., while the publications of the Geological Survey will include geological and economic maps, and reports upon general and economic geology, with the necessarily connected palæontology, and it is recommended that if the collections made by these departments are no longer required for the investigations in progress they should be transferred to the National Museum.

The report also recommends that of the publications of the Coast and Interior and the Geological surveys, besides the copies which may be ordered by Congress for its own distribution, three thousand copies be printed for scientific exchanges, and for sale at the price of publication — advice which it would be gratifying to see followed in some of our own scientific departments.

MINERALOGY.

Manganosite.—This curious mineral, first described by Blomstrand, of Lund, has recently been subjected to a closer examination by Klien. It occurs in dark coloured irregular grains enclosed in granular calcite; and, according to Blomstrand, they have a deep emerald-green hue, while by transmitted light they appear to have a ruby-red colour. The new species is of interest from its consisting of manganese protoxide; the occurrence in nature of so unstable a compound is remarkable. A freshly-fractured surface after exposure to the air for a few weeks becomes covered with a brown layer of oxide. Klien states that the mineral is cubic, and exhibits a fine dark green colour both by reflected and by transmitted light; and he has arrived at the conclusion that the red colour observed by Blomstrand was an effect of oxidation. The granules of manganosite, sometimes 1 cm. in diameter, are imperfectly formed octahedra. The forms produced by etching the crystals are four-sided pyramids with quadratic base.—*Jahrbuch für Mineralogie*, 1878, 750.

Iodobromite.—The "Schöne Aussicht" mine at Dernbach, near Montabaur, in the province of Nassau, which during the last few years has yielded fine specimens of beudantite and crystallised scorodite, has again attracted the attention of mineralogists from the fact that Von Lasaulx has recently found there a mineral which is not only curious as being the first compound of silver met with in that locality, but as new to science, and of peculiar interest

because it forms the first instance of the occurrence of this metal in nature in combination with the hyaloid elements: chlorine, bromine, and iodine. The composition of iodobromite, as he has termed it, is:

	Found.	Calculated.
Silver . .	59·96	60·88
Iodine . .	15·05	14·15
Bromine . .	17·30	17·18
Chlorine . .	7·09	7·79
	99·40	100·03

In the third column of the above table are given the percentage numbers corresponding with the formula 2Ag (Cl Br) + Ag I, which appears to be that of the new mineral. Iodobromite occurs in small regular octahedra of a yellow colour, some of them inclining more to the greenish hue of olivine. The crystals have a close resemblance to those of the bromyrite of San Onofre, near Zacatecas, Chañarcilla, and Hüelgot; they are malleable and sectile. None of the specimens of embolite (silver chloro-bromide) hitherto examined contain iodine. The iodides of sodium, zinc, &c., crystallise in forms belonging to the cubic system, and the fact of their being isomorphous with the corresponding chlorides and bromides of these metals points to the probability of the existence in nature of a silver iodide crystallised in the regular system. The silver iodide, as yet met with, has been found in hexagonal crystals closely according in their forms with crystals of greenockite. O. Lehmann has recently prepared (*Zeitschrift für Krystall.* 1877. I. 492) the iodide artificially in crystals which are regular. Von Lasaulx's discovery is of interest in its bearing on the isodimorphism of this group of salts.—*Jahrbuch für Minerologie*, 1878, 649.

Occurrence of Liquid Carbonic Acid in Syenite.—In his "Geological Report of New Hampshire" Howes describes the occurrence of liquid carbonic acid in the microscopic cavities existing in sections of the New Hampshire rocks. Although the number of sections examined was not large, the cavities were never met with in any of the granitic rocks except in a syenite from Columbia, and here they were found in the greatest abundance, and under circumstances which render their occurrence remarkable. The syenite referred to is white, spotted with black; macroscopically orthoclase and hornblende alone were recognisable. In thin sections, however, plagioclase, biotite, quartz, and apatite were seen, and, moreover, calcite, a mineral rarely occurring in granitic rocks. The quartz is present in small amount only, occupying angular interstices between the other ingredients; but each grain is filled with cavities which are quite large, and many of these contain liquid carbonic acid. Its presence in connection with calcite may indicate that calcium carbonate was a constituent of the sedimentary material of which this rock was formed, and that at the temperature at which crystallisation took place a reaction between the silicic acid and the carbonate resulted in the liberation of carbonic acid.—*Amer. Journ. Sc.* 1878, xvi. 326.

PHYSICS.

Determination of the Temperature of Incandescent Bodies by the Spectroscope.—M. Crova contributes a paper to the *Comptes Rendus* on this subject. It follows from the researches of Draper and Becquerel that when the temperature of an incandescent solid increases continuously, the spectrum lengthens towards the violet end. The temperature of the luminous source can, therefore, be measured (1) by the wave-length of the radiation which limits the spectrum towards the violet; (2) by the position of the thermal maximum of the spectrum which approaches nearer to the violet in proportion as the emission-temperature becomes higher; (3) by means of the ratio of the luminous intensity of a determinate radiation λ taken in the spectrum of the source to the intensity of the same radiation in the spectrum of a source of known temperature, compared with the ratio of the luminous intensities of another radiation λ' in the same two spectra. The last determinations can be easily effected by means of a spectro-photometer.

M. Crova has made numerous determinations of the thermal curves of the solar spectrum by means of a linear thermo-electric pile and a very sensitive galvanometer. These curves were rendered comparable with one another by bringing them to the scale of wave-lengths, and reducing, by means of the dispersion curve of the prism, the intensities to those which would correspond to the case of the normal spectrum of constant dispersion. With these he compares the spectrum of the electric light, the lime light, and the ordinary moderator lamp, always representing by 1000 the intensity corresponding to the wave-length 676. He states that, the intensity being the same in the red for the four spectra, the weakening towards the violet varies with each source according to a certain function of the temperature in the following order of increase:—Moderator, stearine candle, gas, lime light, electric light, and solar light.

The Experimental Determination of Magnetic Moments in Absolute Measure is the subject of the essay to which the Cleland gold medal was awarded. Beginning with a notice of Gauss's experiments on the intensity of the earth's magnetism, it states that no experiments have been published to determine the magnetic moments of steel magnets of different temper and tempered by different methods, giving information as to the permanence of their magnetism after a considerable time.

A reflecting magnetometer was used, consisting of a small mirror 1 centim. in diameter, carrying cemented to its back four small needles about ·8 centim. long, and suspended by a single silk fibre. Two arms of wood rotate round this, their upper sides level with the centre of the mirror, and grooved with a V-shaped depression in which the magnet to be tested could be laid. It could thus be made to form any angle with the magnetic meridian, and the apparatus could be used either on the method of sines or of tangents. The image of a fine wire was brought to a focus on a scale of half millimetres placed at a distance of a metre from the plane of the mirror. A large number of cylindrical steel bars were cut from one piece, and carefully filed to a uniform length of 5 centim. About sixty were raised to bright red heat, and plunged into water of 15° C. They were then made up into parcels of five and placed in a vessel containing oil. These parcels were removed at

successively increasing temperatures from 100° up to 310°. The heated oil was used also to temper a number of parcels by plunging them at a bright red heat into the oil at various temperatures.

All the bars were then magnetised by the current from ten Tray Daniells passing through a coil the same length as the bars, containing four layers of forty turns each, or 160 turns in all. The magnetising force was calculated at 377.

The value of the horizontal component of the earth's magnetic force at the place was computed by observing the period of oscillation of five separate magnets in reversed positions. The mean result, without correction for induction, was ·15399.

The magnets originally named were then magnetised a second time by a double battery and a coil of ten layers and seventy turns, giving a magnetising force of 1100. To show the relative effects of different magnetising forces on bars tempered "glass-hard" and "blue," two bars were brought, one to each of these tempers, and then magnetised, first with very small magnetising force, increased by measured amounts. The results are given in two compared curves, of which abscissæ are proportional to magnetising force, and ordinates to magnetic moments. The blue magnet is seen to rise more rapidly and to a higher point of saturation, though from 300 to 1,000 of abscissæ the two run near together and all but parallel, the blue slightly above the "glass-hard."

Magnets made of steel, suddenly cooled in cold water, were scarcely so strong as those which had afterwards been heated in oil up to 310° C., and allowed to cool slowly. By a second and stronger magnetisation, this difference was much diminished, probably from the softer steel being more easily raised to saturation. Bars cooled in cold oil had small magnetic moment; but this factor increased as the oil was raised to 150° C. It then amounted to 60 to 80 per gramme weight.

Homogeneous iron, or "mild steel," was also experimented on. In a "glass-hard" condition its magnetic moment was only 20·22, and at a blue temper little more than half this.

As regards permanence of the magnetism, it was little changed by nine months' undisturbed quiescence. The hard magnets lost about 2 per cent. of their moment when allowed to fall three times, with true north pole, down from a height of 70 centim. on a hard paving-stone. Blue magnets lost 10 per cent. After nine months the hard lost 0·5, and the blue 2·8, by the same treatment. The essay concludes with a series of tables embodying the above facts in a numerical form.

Binaural Audition.—The principal conclusions which Professor S. P. Thompson comes to on this subject are:—

(1.) There is interference in the perception of sound; for two simple tones capable of interfering are still heard to interfere when conducted separately to the two ears.

(2.) When two simple tones in unison reach the ears in opposite phases, the sound is localised at the back of the head.

(3.) The localisation of this acoustic "image" is independent of the pitch of the sounds.

(4.) When the difference of phase is partial, the sensation is localised, partly in the ears, and partly at the back of the head.

(5.) When two simple tones are led singly to the ears no differential tone is heard. There is some evidence that summational tones are heard.

(6.) In binaural audition dissonances are excessively disagreeable, and consonances harsh.

The Stability of Cleopatra's Needle.—A curious controversy has arisen in the columns of the "Times," and other papers, on this subject. The idea of any real instability no doubt arose from the unusual form of the monument, and the common error in estimating its dimensions. It seems the section is nowhere less in diameter than five feet; and, that being the case, it has been computed that it is competent to stand a wind pressure of 80 to 90 lbs. per square foot. It is said, however, that on January 30, 1868, at the Liverpool Observatory, the anemometer, which registers up to 60 lbs., was driven far beyond its limit, and that the pressure registered could not have been less than from 70 to 80 lbs. on the square foot. It is stated by the authorities that the maximum wind pressure in this country does not exceed 55 lbs. on the square foot. Mr. Dixon illustrated the subject by comparing the alleged pressure to the weight on the floor of a crowded room, which can attain from 80 lbs. to 120 lbs.; the latter with labourers of large stature packed as closely as possible. Thus, he remarked, as the windows certainly have to bear an equal strain with the walls, would anyone dream of standing on a floor formed of glazed window sashes? This *reductio ad absurdum* was, at first sight, conclusive against the accuracy of the anemometer. But Professor Unwin points out that, taking a plate of glass 2 feet in diameter, $\frac{1}{8}$-inch thick, and loaded with 80 lbs. per square foot, we get the greatest stress as = 4270 lbs. per square inch. Now the tenacity of glass has been found to be from 4,200 to 6,000 lbs. per square inch. Hence it is really possible that a pane of 2 feet in diameter might sustain the supposed load, if uniformly distributed, without breaking.

Mr. Dixon further declares that 130 lbs. of wind pressure would not upset it. This estimate, however, seems to need modification. "While," says a contemporary, "if a pressure of 80 lbs. is reached, it is very questionable if the survivors among the inhabitants of the neighbourhood will find it *in situ* when they have time to go to look for it."

On the Illumination of Lines of Molecular pressure, and the Trajectory of Molecules.—Mr. William Crookes read an important paper before the Royal Society on December 5 upon the above subject.

He has examined the dark space which appears round the negative pole of an ordinary vacuum tube, when the spark from an induction-coil is passed through it. The following are some of the propositions he arrives at:—

1. Setting up intense molecular vibration in a disc of metal by electrical means excites molecular disturbance which affects the disc and the surrounding gas. With a dense gas the disturbance extends only a short distance from the metal; but as rarefaction continues, the layer of molecular disturbance increases in thickness. In air at a pressure of ·078 millimetre this disturbance extends for at least 8 millimetres from the surface of the disc, forming an oblate spheroid around it.

2. The diameter of this dark space varies with the exhaustion; with the kind of gas in which it is produced; with the temperature of the negative pole; and, in a slight degree, with the intensity of the spark. For equal degrees of exhaustion it is greatest in hydrogen, and least in carbonic acid.

3. The shape and size of this dark space do not vary with the distance separating the poles, nor, except slightly, with increase of battery power; nor with intensity of spark.

He has devised many experiments to ascertain if this visible layer of molecular disturbance is identical with the invisible layer of molecular pressure, with the investigation of which he has for some years been occupied.

The Electrical Radiometer is made with aluminium-vanes coated with a film of mica. The fly is supported by a hard steel cup, and the needle point is connected with a platinum terminal sealed into the glass. At the top of the ball another terminal is sealed in. The fly therefore can be made the negative pole of an induction coil. When thus connected, a halo of velvety violet light forms on the metallic sides of the vanes, a dark space separating the violet halo from the metal. At the pressure of half a millim. the dark space extends to the glass, and positive rotation commences.

On continuing exhaustion the dark space further widens out, and appears to flatten itself against the glass, rotation becoming very rapid.

With an aluminium cup the conveyance of these lines of force to a focus on the concave side was observed. At very high exhaustions the dark space fills the tube, and at length the tube becomes beautifully illuminated by greenish yellow phosphorescent light. In an apparatus constructed for observing the position of the focus it was found that this is at the centre of curvature, the molecules being projected in a direction normal to the surface of the pole.

The spectrum of the green light is continuous, while that seen at lower exhaustions is characteristic of the residual gas. It is the same whether the residuum be nitrogen, hydrogen, or carbonic acid. It commences at different exhaustions in different gases.

The rays exciting this phosphorescence radiate in straight lines from the negative pole, casting strongly defined shadows of objects in their path. The ordinary luminousness of vacuum tubes will follow any number of curves and angles. From an examination of these shadows and other experiments he advances the theory that the induction-spark actually illuminates the lines of molecular pressure caused by electrical excitement of the negative pole.

The thickness of a dark space is a measure of the mean length of the path between successive collisions of the molecules. The extra velocity with which the molecules rebound from the excited negative pole keeps back the more slowly moving molecules which are advancing towards that pole. The conflict occurs at the boundary of the dark space where the luminous margin bears witness to the energy of the collisions.

When the exhaustion is sufficiently high, the rebounding molecules spend their force on the sides of the vessel, and the production of light is the consequence of this sudden arrest of velocity. The light actually proceeds from the glass. The shadows are not optical but molecular, revealed by the luminous effect. Experiments are given to show that an actual material blow is given by the molecules. The stream is very sensitive to magnetic influence, the action of the magnet being to twist their trajectory round, in a direction at an angle to their free path, the twist being that of the current

passing round the magnet. Great heat is evolved when the concentrated focus of rays from a nearly hemispherical aluminium cup is deflected sideways to the walls of the glass tube by a magnet. It may even be raised to the melting-point of platinum.

Mr. Crookes speculates on the "ultra-gaseous" state of matter, in which, under great rarefaction, the free path of a molecule is made so long that the hits in a given time may be disregarded in comparison to the misses, the properties of "gaseity" are reduced to a minimum, and the matter exalted to a state in which very decided, but hitherto masked, properties come into play. This reveals a new world, wherein matter exists in a fourth state, where the corpuscular theory of light holds good, and where light does not always move in a straight line; but which we must be content to observe and experiment on from the outside.

Some Recent Acoustical Researches.—The harmonic overtones which accompany a musical note are a well-known phenomenon, and their nature has been made pretty clear. There is another phenomenon presenting a certain analogy to this. It has lately been studied by a German physicist, Herr Auerbach, who applies to the notes generated the corresponding name of undertones. These undertones may be had by striking a tuning-fork vigorously, then placing its stem very lightly on a sounding-board. One hears the lower octave of the fundamental note of the tuning-fork. With suitable materials, Herr Auerbach also obtains the lower fifth of the lower octave, and the lower fourth of this tone—that is, the double octave of the fork's tone; in fact, these resonance tones form a series of harmonic undertones. The phenomenon appears to depend essentially on the strength of the vibrations and the imperfect elasticity of the resonance-surface of the plate. Herr Auerbach has tried a variety of substances for undertones with tuning-forks. He finds that some, indeed most, substances give these tones; that some give only a noise, as soon as the vibrations are moderately strong; and some always give the tone of the fork, no matter how strongly this is sounded. Another German observer, Herr von Strouhal, has recently given some attention to a kind of tones not much studied hitherto—viz., those which arise when a rod is quickly swung through the air, or when currents of air impinge on stretched wires or sharp edges, &c. For pureness of tone, the swung rod must have all its parts moved with the same velocity, and it must be cylindrical. Herr Strouhal made an apparatus consisting of a vertical wooden column with two horizontal arms, between which the bodies to be forced through the air (mostly wires) were fixed, and he rotated the frame in its upright position at various speeds. Thus he got notes which rose in intensity and pitch with the speed. He found that the pitch of the "friction tone" (as he calls it) is independent of the tension of the wire, likewise of its length. But the length of the wire has a marked influence on the intensity of the tone. The longer the wire, the stronger (*cæteris paribus*) the tone. Further, the substance of the body is a matter of indifference; but the height of the tone is directly proportional to the velocity of motion, and inversely so to the diameter of the wire. The author finds, moreover, that there is a way of making the "friction tone" produce the wire's own tone—viz., when it is brought up to the same pitch with this (the wire being preferably thin and elastic), and similarly, by raising the pitch gradually

higher, the succession of overtones of the wire are generated. The distinct character of the general phenomenon above indicated appears from the fact, among others, that with rising temperature the friction tone becomes lower. The true nature of these tones is at present somewhat obscure. Herr Strouhal offers, with reserve, an interpretation of the facts, for which, however, we must refer to his original paper in the "Annalen der Physik und Chemie."

The Nature of the Elements.—Mr. J. Norman Lockyer read an elaborate paper on this subject before the Royal Society on Dec. 12. He discussed the evidence obtained from spectroscopic observation of the sun and stars, leading to the conclusion that the so-called elements of the chemist are in reality compound bodies. The method by which Mr. Lockyer proceeds was explained in the last number, while reviewing his recent work "Studies in Spectrum Analysis." By turning the slit of the spectroscope through 90°, and throwing an image of the luminous body on it by means of a lens, he is enabled to study the various regions of the heated vapour, and to establish the fact that all the lines in the spectrum of the substance volatilised do not extend to equal distances from the poles. It is found that the lines furnished by a particular substance vary not only in length and number, but also in brightness and thickness according to the relative amount present. About four years ago Mr. Lockyer commenced a map of the spectrum of the sun on this principle, with a view of ascertaining more definitely than has hitherto been possible which elements are present in it. A collateral result of this important work is to show that the hypothesis that identical lines in different spectra are due to impurities is not sufficient; for he finds short-line coincidences between the spectra of many metals in which the freedom from mutual impurity has been demonstrated by the absence of the longest lines. There are, moreover, many facts which point to another hypothesis, namely that the elements themselves, or at all events some of them, are compound bodies. Thus it seems that the hotter a star the simpler its spectrum, for the brightest, such as Sirius, furnish only very thick hydrogen lines and a few very thin metallic lines, characteristic of elements of low atomic weight; while the cooler stars, such as our sun, are shown by their spectra to contain a much larger number of metallic elements than stars such as Sirius, but no non-metallic elements. The coolest stars furnish fluted band spectra characteristic of compounds of metallic with non-metallic elements. The facts are easily explained if it be supposed that as the temperature increases the compounds are first broken up into their constituent "elements" and that these "elements" then undergo dissociation or decomposition into constituents of lower atomic weight. If A contains B as an impurity, or as a constituent, in both cases A will have a spectrum of its own. B, however, if present as an impurity, will merely add its lines according to the amount present, whereas if a constituent of A it will add its lines according to the extent to which A is decomposed and B set at liberty. So as the temperature increases the spectrum of A will fade if A be a compound body, whereas it will not fade if A be a true element. Moreover if A be a compound body, the longest lines at one temperature will not be the longest at another.

From this point of view, the spectra of calcium, iron, hydrogen, and lithium are observed at different temperatures. It is shown that precisely

the same change as is to be expected on a hypothesis of the non-elementary character of the elements is found to take place. Thus each salt of calcium below a certain temperature has a spectrum of its own, but as this rises, fine lines due to the metal appear in the blue and violet. In the electric arc the violet H and K lines are still thin. In the sun they are very thick. Both are present in *a* Aquilæ, the latter only half the breadth of the former. In *a* Lyra and Sirius only the H line of calcium is present. In solar storms, the H line has been seen injected into the chromosphere seventy-five times, the K line fifty times, but the blue line, which is the all-important line of calcium at the arc-temperature, was only injected thrice.

Iron and lithium exhibit analogous changes.

As regards hydrogen, its most refrangible line *h* is only seen with very high temperature; it was absent from the solar protuberances in the eclipse of 1875. By employing a very feeble spark at low pressure, the F line of hydrogen in the green is obtained without the blue and red lines seen when a stronger spark is used.

Mr. Lockyer has obtained evidence leading to the conclusion that the substance giving the non-reversed line in the chromosphere, termed *Helium*, and not previously identified with any known form of matter, and also the substance giving the 1474 or coronal line, are really other forms of hydrogen, one more simple than that which gives the *h* line alone; the other more complex than that which gives the F line alone.

The Music of Colour and Motion.—Profs. Ayrton and Perry read a curious if somewhat fanciful paper on this subject before the Physical Society on Nov. 23. They began by assuming that emotion is excited by moving bodies, and expressed their belief that upon this basis a new emotional art would be created which would receive high development in the future. All the senses they believed could be cultivated into emotion. One of these, music, from the facility with which its effects could be produced, had alone been highly perfected by the bulk of mankind. Sculpture and painting they held to be not purely emotional, inasmuch as they involve thought. It would take long time and culture for the eye to behold moving figures with similar emotional results to those produced through the ear on hearing music. Indeed the Eastern nations seemed to have cultivated this faculty more highly than those of the West. The Orientals had entertainments consisting of motion and dumbshow which, though incomprehensible and even ludicrous to the European, powerfully affected the feelings of a native audience. In Japan they had seen whole operas of "melodious motion" expressed by movements and gesticulations of the body. In illustration, Blackburn's pendulum, Lissajou's forks, Wheatstone's Kaleidophone, Yeates' vibrating prisms, Donkin and Tisley's harmonographs, and other like contrivances were exhibited. In none of these, however, is the production of mere emotion the end in view. A successful instrument in the new kinematical art must at least visibly render changes in period, amplitude, and phase. Such an instrument they had devised and constructed in Japan, and it was described by means of diagrams and photographs. As far as could be thus made out, it appeared to be an ingenious contrivance for producing and modifying compound harmonic motion. They intend constructing an improved form of the apparatus, and to arrange for

the blending of colour with the moving body, to heighten the emotional influence. In the discussion which followed, the opinion was expressed that though the writers had done good service in pointing out the educability of the various senses, and the parallelism which runs through their æsthetical use, they had not even attempted to prove that the pleasure experienced on looking at graceful and regular figures amounted in any sense to emotion. To fulfil that indication it should move to tears, incite to heroic deeds, or stimulate to pity and charity. This music, which had the undoubted power of suggesting noble ideas, was well known to do, as had been grandly described in the "Alexander's Feast" of the poet Dryden. In giving an extended and somewhat metaphorical sense to the word music, they were only recurring to the original meaning of the Greek word, which included all forms of artistic enjoyment. At most, the contemplation of graceful curves and harmonious colour could gratify the sense of proportion, and might in the mind of a mathematician produce some sentiment akin to beauty; all beyond must be due mainly to association. If their argument were carried to its bitter end it might be suggested that the praying machine of the Buddhists would "in time and by cultivation" beget a sense of religion in the worshipper who turned its handle.

Magnetic Rotation of the Plane of Polarisation of Light under the Influence of the Earth.—This has been studied by M. Henri Becquerel, and the result communicated to the Académie des Sciences. Between a Jellett polariser and a telescopic analyzer mounted on a divided circle is placed a tube half a metre in length, terminated by parallel plates, and containing carbon bisulphide. Mirrors at the ends of the tube give successive reflections, and augment the observed rotation. In this experiment the ray traversed the tube five times, thus corresponding to a length of 2·5 metres of carbon bisulphide. The light was oxy-hydrogen. Much light was lost, and the rays transmitted were chiefly yellow.

It was found that if the system were made to coincide in direction with the plane of the magnetic meridian, the same position of the plane of polarisation is not obtained by looking north or south, there being a difference of about 6′·5 between the two positions. When it was placed perpendicular to the magnetic meridian, the plane of polarisation was the same on looking east or west.

It may be concluded that this rotation of the plane of polarisation is due to the action of the earth. Its direction is the same as that of the earth's direction, and the same as that of an electric current which, on the hypothesis of Ampère, would give rise to the phenomena of terrestrial magnetism.

The apparatus described showed also great sensitiveness to the action of magnetism: an ordinary bar magnet held in the hand, and brought parallel to the tube, first in one direction, and then in the other, is sufficient to cause a rotation of the plane of polarisation of more than 1°.

"It is interesting," says M. Becquerel, "to compare this direct measurement with an estimation by Mr. Gordon, in the 'Philosophical Transactions for 1877,' of the magnetic rotation produced by 1 centim. of carbon bisulphide under a magnetic action equal to unity. The result is that 2·5 metres should give with yellow light a single rotation of 3′·8, instead of 3′·25, which is the result of observation.

PHYSIOLOGY.

On the Effects of Varnishing the Skin in the Lower Animals.—At least since the time of that Pope of Rome who varnished an unfortunate urchin into the semblance of a golden child, the fatal effect of coating the skin of animals with impermeable varnish has been well known. While a certain portion of the skin may be thus coated without producing serious derangement of the organisation, when the proportion reaches to about one-sixth, death can only be avoided by a considerable increase of the temperature in which the animal is kept. It was supposed that these phenomena were due to the suppression of the functions of the skin, which caused a retention of excrementitious matter in the system, giving rise to a form of toxæmia. Another explanation, however, of the fatal results produced by body-varnishing was ably advocated in 1868 by Laschkewitch, who attributed death to the rapid loss of heat experienced by varnished animals, and this view appears until recently to have been very generally received. Latterly, however, the older explanation has been supported by Lange and Sakolow, which has led M. Lomikowsky to reinvestigate the subject, particularly with the object of ascertaining the cause of the rapid decrease of temperature in varnished animals. With the help of the thermomultiplier, he has been able to prove that the radiation is much greater from varnished than from unvarnished animals, the difference being quite sufficient to account for the loss of heat and the fall of temperature, while the symptoms observed during life and the changes observed in the viscera after death are fully accounted for by the cooling, being in fact identical with those found in animals killed by exposure to cold. With universal varnishing, as with extreme cold, death occurs rapidly, while a more moderate cold or a partial varnishing excite inflammatory changes in the internal organs, more particularly in the kidneys, and cessation of life indirectly ensues as a consequence of uræmia.

ZOOLOGY.

Reproduction of Hydra.—M. Korotneff has arrived at very different conclusions from those of Kleinenberg upon this subject. According to the latter the reproductive cells occur below the ectoderm and form a mass which serves for the production of both ova and spermatozoids. The process described by him is as follows: one of the cells of this mass increases considerably and swallows up the surrounding cells, or, in other words, feeds upon them. The nucleus then becomes transformed into a germinal vesicle and finally the cell comes to represent the ovum of the *Hydra* which is thus in its origin a unicellular and ectodermal formation. The granulations of the ovum serve to produce the larger elements described by Kleinenberg under the name of *pseudo-cells*. The blastoderm, according to Kleinenberg, is formed immediately after the conclusion of segmentation, and consists of a layer of cells forming the whole envelope of the ovum. It is regarded by him as an embryonic epithelium, taking no part in the ultimate formation of the *Hydra*, but to be rejected at a certain period of development. Hence the adult *Hydra* is destitute of epithelium.

The author, like Kleinenberg, has observed an agglomeration of cells of ectodermic origin, but regards them merely as embryonic cells, serving to reproduce different ectodermic elements. One of these cells increases, and its nucleus is converted into a germinal vesicle; while at the same time the peripheral elements of the mass separate, forming a row of cells with very small refractive granules, and the central cells unite with each other and with the enlarged cell, forming a common plasmodium sprinkled with numerous nuclei. The germinal vesicle is degraded and disappears entirely; the nuclei of the central cells increase a little in volume and degenerate into fatty bodies, and some of them divide. These are probably Kleinenberg's pseudo-cells. The peripheral elements of the mass sprinkled with chitinous granules form the envelope of the ovum. M. Korotneff concludes that Kleinenberg mistook these peripheral elements for a blastoderm, and the mass of central cells for the result of a true segmentation.—*Comptes Rendus*, September 9, 1878.

The Buzzing of Insects.—M. Jousset de Bellesme objects to the theory of the cause of buzzing in insects proposed by M. Perez as noticed in our last number. He remarks that all insects in which the wings make more than eighty vibrations per second emit a perceptible sound which is suppressed by the removal of the wings. The diptera and hymenoptera emit two sounds—that just mentioned, which is deep; and another sharper sound, generally the octave of the former. This is the essential characteristic of buzzing. When the wings are cut off a *Volucella* or humble-bee, the deep sound is abolished, but the sharper one persists. The former is therefore produced by the wing, while the latter is independent of it.

M. de Bellesme agrees with M. Perez that this sound is not connected with the passage of air through the thoracic stigmata, and he seeks its cause in the mechanism by which the wing is set in motion. He says that in buzzing insects the muscles of flight are not inserted directly upon the wing, but upon the pieces of the thorax which carry it, and that it is the movement of these that causes that of the wing. The thorax, therefore, undergoes continual changes of form under the contraction of these motor muscles. In repose a section of this region represents a vertically elongated ellipse, which the action of the muscles converts into a horizontally elongated ellipse. The entire thorax, therefore, vibrates successively in the direction of its two diameters; and, as the muscles are very powerful, the vibratory movement is very intense, and the thorax constitutes a vibrating body which acts directly upon the surrounding air. The thoracic sound is higher after the wings are cut away. This is because during flight the resistance of air acting upon the wings diminishes the velocity of contraction of the muscles. By attaching a style to the upper wall of the thorax after the removal of the wings the author was enabled to inscribe these vibrations, and obtained traces in which the number of vibrations corresponded exactly to the sound produced. —*Comptes Rendus*, October 7, 1878.

The Poison Glands of the Centipedes.—It has long been known that the Chilopod Myriopoda, commonly known as Centipedes, which are carnivorous in their habits, kill their prey by a poison injected at the first bite of their formidable nippers. The seat of the glands secreting the poisonous fluid was, however, unknown, the organs formerly supposed to secrete the venom being

found to pour their secretion into the cavity of the mouth, and not into the nippers. Mr. M'Leod, during a residence in Java, took the opportunity of examining some of the large centipedes with which that island abounds, and especially *Scolopendra horrida*; and finding that, as above stated, the glands which might easily be taken for poison glands had nothing to do with the nippers, which, nevertheless, always exhibited a very distinct orifice at the tip, he was led to search for the glands in the interior of those organs themselves.

The process he adopted is one that has of late given admirable results in the investigation of the anatomy of many animals; namely, the preparation of sections of them in various directions after they had been immersed in melted paraffin, the subsequent hardening of which keeps all parts in their natural positions during the operation of cutting. By this means he detected the poison gland, which is situated partly in the actual biting portion of the nipper, and partly in the broad basal joint which supports the latter. The glandular apparatus consists of a chitinous duct leading to the orifice at the apex of the organ, and forming the axis of the gland. It is perforated in its course by a multitude of small apertures, each of which leads into a minute cylindrical tube terminating in a long secreting cell, the whole mass of these cells being arranged in a radiating fashion around the duct. The entire organ is surrounded by a membrane, and has the general form of a four-sided prism. Notwithstanding its comparatively small size, Mr. M'Leod has detected the same arrangement in *Lithobius forficatus* (the common European centipede).—*Bull. Acad. Roy. de Belgique*, tome xlv. 1878.

Sponge-borings in Marble.—Most naturalists are aware of the power possessed by certain sponges forming the genus *Cliona* of boring into the shells of mollusca and other hard bodies, but we are hardly prepared to hear of their making their way into so refractory a substance as statuary marble. Prof. Verrill, however, states (*Silliman's Journal*, November, 1878) that the Peabody Museum of Yale College has lately received some fragments of white Italian marble from a cargo wrecked off Long Island in 1871, and taken up this year, in which "the exposed portions of the slabs are thoroughly penetrated to the depth of one or two inches by the crooked and irregular borings or galleries of the sponge *Cliona sulphurea*, V.," and reduced "to a complete honeycomb readily crumbling in the fingers. Beyond the borings the marble is perfectly sound and unaltered." Prof. Verrill remarks that the possession of such boring powers by this apparently insignificant sponge may have a practical bearing in the case of submarine constructions of limestone or similar materials.

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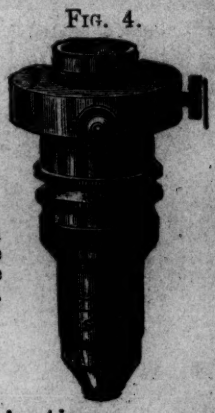

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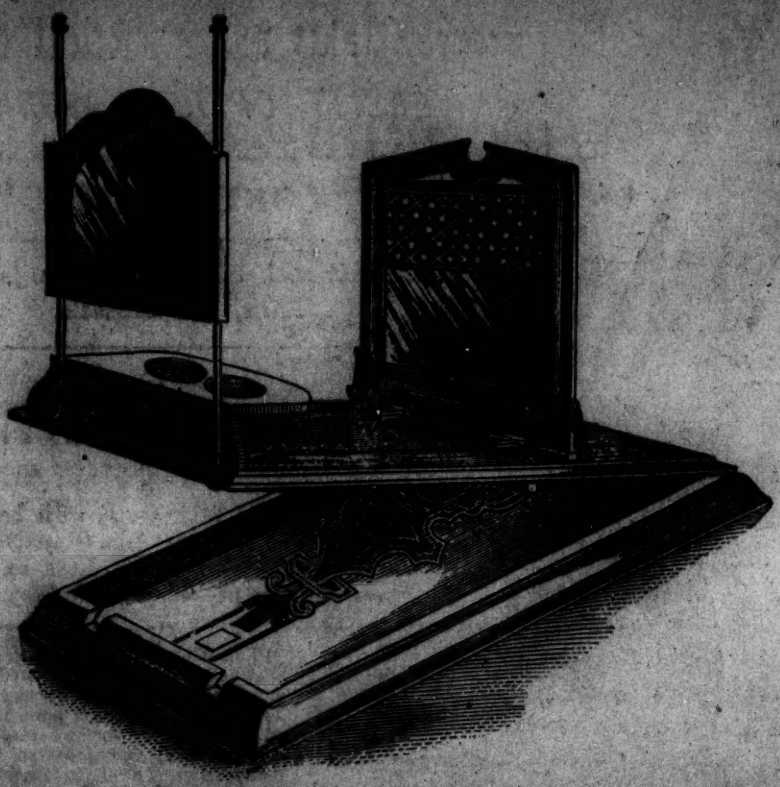

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